NO. HW2
MAY 1956

JOURNAL of the

Highway Division

PROCEEDINGS OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS

VOLUME 82

THIS JOURNAL

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This Journal is published by the American Society of Civil Engineers. Publication office at 2500 South State Street, Ann Arbor, Michigan. Editorial and General Offices at 33 West 39 Street, New York 18, New York. $4.00 of a member's dues are applied as a subscription to this Journal.

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HIGHWAY ENGINEERING MANPOWER—RECRUITING AND TRAINING OF GRADUATES

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(Proc. Paper 983)

SYNOPSIS

There are two sources of recruitment for filling the need for highway engineers—high school graduates and college civil engineering graduates. Highway departments should give more attention to selecting, training, and managing employees than to equipment and materials. Equipment and materials are important, but without manpower to direct their use, they can accomplish nothing. Proper training of high school and college engineering graduates after employment will pay dividends in the long run. Of great importance also are conditions after employment, which means a well-planned and well-operated personnel management program.

INTRODUCTION

The human mind and the human hand are still the foundation of highway progress. Science and technology can continue to develop electronic machines and power road equipment, but no progress can be made in overcoming the $101 million backlog of highway needs until human minds decide what, where, when, and how the construction is to be accomplished. Human hands have to sign the official papers and plans which put the program into force. And from then on progress is dependent on the human management of men, machinery, materials, and money.

For the most important phases incident to getting into motion a larger highway program we must rely upon engineering and its associated operations as performed by the highway engineers, bridge engineers, and material engineers and their helpers known as subprofessionals and technicians. Herein, as is well-known but not fully appreciated by many public officials, lies the manpower through which highways are planned, designed, and built. Any

Note: Discussion open until October 1, 1956. Paper 983 is part of the copyrighted Journal of the Highway Division of the American Society of Civil Engineers, Vol. 82, No. HW 2, May, 1956.

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analysis of how to manage an enlarged highway program will include attention to recruiting, training, and holding technical employees in highway departments—county, city, State, and Federal.

The qualifications of employees capable of filling the engineering, subprofessional, and technician positions are found in two sources of recruitment—high school graduates and college graduates in engineering. These two sources will be examined and then an after-hire training and personnel management program will be discussed. But first, it is well to look into the general personnel management policies of highway departments.

Lack of Attention to Manpower

Employees of a highway department are a working material somewhat in the same light that steel, aggregate, cement, soil, asphalt, and power equipment are road building materials. Research and development of these physical materials and equipment has been a major attention of highway officials dating back to the beginning of this century. But what about the human material? Only recently has the highway literature been blessed with attention to the selection, training, and management of employees. It is encouraging that the highway officials are now overcoming their many years of neglect in this important area of management.

There should be a greater importance attending the selection, training, and management of employees than that given to materials and equipment. Wipe out a highway department, but leave behind a staff of well-trained employees and the department can recreate its organization. But take away the staff and leave only the physical materials and rebuilding becomes impossible. This fact assures us that if we can employ qualified persons and then manage them satisfactorily, we can successfully complete the highway program the country needs.

Keeping this No. 1 position of employees in mind, it is in order to examine the sources of supply for qualified employees in the technical areas. Acknowledgment is made of the importance of administrative, clerical, fiscal, legal, and other classifications of employees, but before this audience of engineers, it is appropriate to confine present discussion to engineers and their assistants.

The High School Graduate

Advances in the training of high school students now make it possible for highway departments to hire high school graduates for a large number of duties that formerly were considered assignable only to college graduate civil engineers. Similarly, the duties of the college graduate engineer are being advanced from surveying, testing, drafting, and computing to those areas where greater engineering judgment is required.

The three essentials to staffing the highway department with qualified high school graduates and keeping them employed are (1) recruiting, (2) training while employed, and (3) personnel management.

Successful recruiting of the high school graduate depends upon getting to him when he is a student sufficient information so that he understands the character of highway work that he may do. Through this information he may reach a state of mind whereby he can be convinced that he should begin a career in highway work as a high school graduate. Even though the graduate

may later elect to attend engineering college, there is much to be said in favor of a summer's work with highways between high school and college.

Proper education of the high school student about the operations of highway departments and employment therein involves seeing that his parents, his teachers, and present employees of the highway department are informed and that they fully understand what such employment consists of.

It may be assumed that the high school student on occasion has followed the advice of his parents and of his teachers, though teenagers are prone to work out their own salvations and to accept the advice and understandings of their own set with greater willingness than from "grown-ups." Nevertheless, a program is in order to see that the adult population within a community is correctly informed about highways and its opportunities for employment. The various civic clubs are excellent outlets for informal discussions about highways. The local newspaper might run a series of feature articles on highways and highway personnel. High school career day is a No. 1 important opportunity by which high school seniors can be given correct information about highways. Motion pictures, promotional booklets, and descriptions of completed projects, offer desirable media through which to interest the student in highway work. Tours through headquarters operations and district operations could be used to advantage in much the same way that private concerns handle inspection and tours.

The general filtration of knowledge about highways into the minds of high school students should begin with their entry to senior high to prepare them for their decision in the spring of their senior year. However, remembering that there is a large and widespread competition for the services of high school graduates, the highway department personnel officer must get personally on the job and interview those seniors who can be reached. Students must be gone after—to their homes, to their schools, and by direct and personal invitation to come to the highway department to discuss employment.

A high school graduate properly informed at this age may thereby be encouraged to select civil engineering as his college major, whether or not he may take employment in the highway field immediately upon finishing high school. Highway officials should view all recruiting efforts on the long time results and not on the particular results of a given year.

Training High School Graduates

Perhaps one of the better selling elements to a high school senior who is being sought for highway employment is a positive training program combined with a positive development and advancement program. Though probably to a lesser extent than with the college graduate, the high school graduate in seeking employment looks for more than just a paycheck. And more than fringe benefits too. He desires opportunity for advancement in responsibility and for a long tenure of satisfying employment.

What can the high school graduate do in highway work associated with engineering responsibilities? For what should he be trained during employment? His training should be directed to field surveying with ultimate party chief responsibilities, field sampling and testing of materials, concrete and bituminous plant inspection, and a host of items in the field office details of the resident engineer.

In most any engineering office the high school graduate can be trained to perform calculating, tabulating, plotting, drafting, tracing, and cross section

work. In addition, the materials and testing laboratory offers the high school graduate ample opportunity to become skilled in the performance of standard testing procedures and in the making of chemical and physical analyses.

One great advantage of training high school graduates to perform subprofessional and technician duties is that he is more willing to continue doing them for a much longer time than is the college graduate. He will recognize that the lack of a college education places a ceiling on his advancement.

In training high school graduates for these subprofessional positions, the better approach is through a planned program under the guidance of trained instructors. Instruction in surveying and drafting can be arranged for through many of the engineering colleges and through technical institutes. For other training more particularly associated with a particular highway department, classes can be organized within the highway department and taught by employees having aptitude for such teaching. Also, normal on-the-job training should be provided through a planned program.

During the training phase, and indeed thereafter, the high school graduate will respond to his employment and training with high morale and interest because the department has given him attention and opportunity. He is likely to reciprocate with rapid learning and enthusiasm for his job.

Personnel Management

But even though a graduate is properly recruited and adequately trained on the job, he will not become the ideal employee unless he can be made happy in his work. Personnel management policies play an important part in the development and maintenance of satisfied employees.

These policies involve the physical conditions surrounding the place of work, chain of command, supervisor attitudes, promotions, overtime, grievances, discipline, employee associations, house organs, credit unions, family attentions, support of community activities, and participation in professional society activities. There are others. A good employer nowadays is expected to direct attention to these matters and to work out jointly with his employees personnel programs and policies of mutual interest.

The College Civil Engineering Graduate

The college graduate in civil engineering is the one source for engineering talent for highway departments. A specific department, however, has for areas of recruitment, other agencies who have in their employment the civil engineering graduate, but all such agencies, in the beginning, are dependent upon the annual college graduating classes for the engineer.

Success in recruiting the civil engineering graduate for highway employment is dependent upon about the same factors as govern success in recruiting the high school graduate. There is this difference, however. The parents and general public play little or no part in the decision of the graduate which leads to his first post-college employment.

The college senior has two basic decisions confronting him. First, what field within civil engineering shall he enter, and second, if he enters highway engineering, what organization and what type of duties shall he choose.

Rightly, from the standpoint of sound education, the college curricula endeavor to train civil engineers, not highway engineers, nor sanitary, municipal,

or structural engineers. Highway departments are, therefore, confronted with the necessity somewhere along the line between high school graduation and college graduation of having a sufficient number of college seniors select the highway field as their choice of employment.

A civil engineering department of a college maintains an instructional staff which, more or less, exhibits a somewhat neutral position toward the various specialities within civil engineering so far as advising students is concerned. However, there is nothing within the teaching code that prevents the professor of highway engineering from advising his students of the opportunities in the highway field. The highway official, in order to receive fair consideration from the college senior when he selects his employer and field of practice, must have done two things: First, taken every opportunity to acquaint the civil engineering student with the facts and probabilities related to highway engineering as a field of practice, and second, taken comparable effort to see that the professors of highway engineering are likewise informed. Undoubtedly, a college professor has great influence over his students. Some colleges can trace year after year the entry of its graduates into particular fields of practice and even to certain employing organizations. Back of these continuing entries into the same employment lies a certain professor with skill as a student counselor.

Selling the college teaching staff on highway employment, including the fact that it is generally Government employment, is the responsibility of highway officials. Perhaps the best way to success in this selling is through personal contracts and personal effort. A highway department can assist college teaching materially by furnishing class and laboratory material, by conducting inspection tours, by giving seminar lectures, and by granting interviews to students on special college assignments and reports. Regular attendance at the meetings of the student chapters of the ASCE is an important duty. Through these meetings, opportunities are had to get acquainted with professors and students alike. They further afford on-the-ground opportunity to observe the students in action and to earmark those of the better employment possibilities.

Active recruiting of the seniors can be made through direct mail in early fall of general literature setting forth highways as a field of employment and the particular highway department as the employer. The follow-up is through the placement channels as operated by each college. Through these channels opportunity is had to interview those students of expressed interest in highway work. At these interviews and through follow-up material the senior must be led into choosing the particular highway department for his initial employment.

When it is known that the average number of job offers to engineering college seniors has been ranging from 5 to 8 per senior, including all companies and all engineers, it is readily seen that the competition is keen. The successful companies operate a full-fledged recruiting plan with well-trained interviewers. These companies have more than salary and fringe benefits to offer. They have highly developed training programs, attractive futures, and honest-to-goodness personnel policies and programs. It is admitted that seniors give attention to starting salaries in making their selection of position, but on the other hand, many seniors turn down high salaries for jobs with greater professional opportunities in the long run.

Training programs for the college graduate are known to influence favorably the choice of many seniors. There is good reason why every State

highway department should have at least a 2-year training program for its newly hired college graduates in civil engineering. Training programs are worth more discussion, but there is not room in this short paper to go into more detail.

Conditions After Employment

Of the two main steps to staffing a highway department with engineers and subprofessionals—recruiting and personnel management—let it be understood that personnel management is of no less importance than recruitment. What good becomes of hiring a high school graduate or a college graduate and then having him resign two to six months later? Yet such resignations are all too frequent. What is the reason for unreasonably short employments? Basically, the reason lies between or among, first, conditions of hire, and second, treatment after hire.

Before accepting employment, the prospective employee is expected to understand the terms of and conditions of employment—location, kind of work, specific duties, supervision, associates, work week, overtime, fringe benefits, duration of employment, promotion policy, and all other factors which bear upon overall satisfaction. If there is not understanding on these items at the time of hire, dissatisfaction may result thereafter. Important it is, then, in the interest of long tenure, to take ample time to make the prospective employee understand these conditions of employment. Full understanding at this time may prevent later unsatisfactory attitudes leading to resignation.

The second element is the management of the employee after hire. First, the conditions of employment as set forth during recruiting must be kept, and second, the employee must be accorded personal attention and given to realize that he is one of the family, that he belongs, that he is among friends, that his present and future welfare are of concern to the employer, and that he has professional security as well as job security.

Perhaps nothing will destroy the morale of a young college graduate quicker than to be associated with employees who belittle their employer, their job, or their opportunities ahead. Bickering, disgruntled, and griping employees are a menace to any organization but particularly to the college graduate. Another source of ill content is to place the college graduate in the hands of a supervisor who came up the hard way, and who is not in sympathy with formal education. A variation of this type of supervisor is the one who is too demanding or too expectant of the graduate, who, after all, is an employee, usually without experience, but one willing and anxious to learn.

Management will do well to follow carefully the employment for the first three years of each high school and each college graduate to determine currently his progress, his morale, his attitude, and his appraisal of his employment.

The Total Recruiting Job

There is need for State highway departments, exclusive of city, county, special authority, and consulting employment, to hire annually about 7,000 high school graduates for subprofessional engineering work and 800 college graduates of civil engineering. These rates are probably twice the current rates of hire. But there is the need for them, and the graduates are available,

particularly with the present upward trend in the number of students enrolled. The 7,000 and the 800 can be hired and a reasonable percentage retained on the employment rolls by a concerted, determined effort by the highway departments assisted by the local sections of the ASCE and other agencies interested in highway construction.

Specifically, the local sections can carry the burden of developing an organized program directed to reaching the public, parents, teachers, and students with the correct information about highways as a field of employment.

In turn, the highway departments can evaluate their need for employment, develop a job classification system, adopt employment policies of that character sufficient to meet the competition for these graduates, and place into operation adequate training programs. The departments should organize a recruiting operation such that every graduate of each high school will be reached and every college civil engineering student will have specific opportunity to make a decision for highway employment after adequate consultation with his professors and with highway officials.

These operations will provide the required technical manpower so badly needed.

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HIGHWAY DIVISION
Proceedings of the American Society of Civil Engineers

HIGHWAY ENGINEERING MANPOWER: ENGINEERING EDUCATION ASPECTS

Harmer E. Davis,[1] A.M. ASCE
(Proc. Paper 984)

SYNOPSIS

This paper summarizes briefly those factors relating to education and training which have a bearing upon the highway manpower problem. The increasing tempo of highway development will require increased output from highway agencies. But it is unlikely that the demands can be fully met from the number of graduates which can be produced by the professional engineering schools in the next few years. However, improved procedures and the increased use of engineering technicians can avoid a crisis.

The purpose of this discussion is to summarize briefly those factors relating to education and training which have a bearing upon the highway manpower problem. The present urgency of the engineering manpower problem, and the various other aspects of the problem, have been treated by other contributors to this panel.

The following observations characterize the situation:

1) The supply of new civil engineering graduates going into highway engineering work falls far short of meeting the demand.

2) The prospects of markedly increasing the numbers of civil engineering graduates in the next year or two are practically nil.

The post-war trend in enrollment in the (accredited) engineering colleges in the United States is given in Table 1. The trend in Civil Engineering enrollments, compared with enrollments in the other major branches of engineering is given in Table 2. The trend in Civil Engineering undergraduate

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Note: Discussion open until October 1, 1956. Paper 984 is part of the copyrighted Journal of the Highway Division of the American Society of Civil Engineers, Vol. 82, No. HW 2, May, 1956.

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enrollments and first degrees granted in Civil Engineering is given in Table 3. Significant points to be drawn from these data are as follows:

1) While engineering college enrollment in the immediate post-war years was 10 percent or better of the total college enrollment, the percentage of engineering enrollment has dropped back to something slightly over 7 percent, which is about what it was just prior to World War II. Engineering college enrollment (in E.C.P.D. accredited colleges) totaled about 187,454 in 1954 and is now increasing at about 8 percent per year.

2) While prior to World War I Civil Engineering attracted the largest number of engineering students of all the branches of engineering instruction, since 1935 the Civil Engineering undergraduate enrollments have been between 10 and 15 percent of the total undergraduate engineering enrollments. In 1954, the total number of Civil Engineering undergraduates in E.C.P.D. accredited schools was 21,560, about 13 percent of the total undergraduate engineering enrollment.

3) While the Civil Engineering departments currently have only about one-eighth of the total undergraduate engineering enrollment, the number of first degrees granted (B.S. or equivalent) is almost one-fifth of the total first engineering degrees granted. In 1954, some 3,597 civil engineers were graduated.

The influence of the current upswing in college enrollments is just beginning to be felt in the senior years, but the effect of this on the number of Civil Engineering graduates is not likely to be felt for another year or so.

An important general observation that is voiced by a number of agencies concerned with this matter is that students are not being attracted to the sciences and engineering at the rate that might be expected from the increases in high school graduates now becoming available. Some observers attribute this to a relatively decreased emphasis on preparatory subjects in the high schools that are a basis for entering the sciences and engineering in the colleges. In addition, it appears that in the engineering schools the appreciable enrollment increases are occurring in subjects that have attracted large public attention, such as electronics.

A net conclusion from the examination of these statistics and trends is that we shall probably not produce the engineering schools in the United States more than 4,000 to 5,500 Civil Engineering graduates per year for the next several years.

Most of the college-trained engineering personnel recruited by the highway agencies are drawn from the Civil Engineering schools. Only a fraction of the Civil Engineering graduates, however, go into highway work. The demands for graduates in other phases of Civil Engineering are extensive. No accurate statistical data are available, but as a rough guide a study recently made at the University of California on the placement of graduates of Civil Engineering, from the classes of 1949 through 1953, showed that 22 percent of these graduates were employed in highway engineering; this may be higher than the percentage in many other schools, however, since considerable impetus is given to this field in California, both by the recruitment activity of the Division of Highways, and by the attention given in the curriculum. With

this figure as a guide, it may be reasonable to expect that the number of graduates of Civil Engineering who will enter highway engineering work throughout the United States will not exceed 1,000 per year during the next few years.

Information is not available to give a good over-all picture of the replacements in highway engineering personnel needed each year. Moyer[2] places an extremely conservative estimate of losses due to deaths, retirements, and transfers out of the field at 2 percent per year. This means a replacement requirement of about 400 per year under present state programs. If an accelerated program at double the present volume were undertaken, the replacements needed would almost equal the current production of new Civil Engineering graduates currently willing to enter the highway engineering field.

There are a number of aspects of the education of engineers for service in highway transportation engineering, which aspects cannot be expressed in the form of statistical trends, although some are trends nevertheless. Following are a few highlights.

1) The pattern of high school curricula which has emerged appears to be placing much less emphasis than formerly on mathematics and scientific subjects. This has two immediate effects: (a) high school students who might otherwise have been motivated to take scientific or engineering studies in the colleges are not so motivated, (b) high school graduates who wish to enter the colleges in the engineering or scientific departments may be either dissuaded from entering such courses of study because of deficiencies, or if they are allowed to enter, their weaker preparation in mathematics and science causes difficulty or slows their progress. This may mean that the colleges will have to recognize this situation for what it is, and adjust entrance requirements (as to subject matter, not scholarship) and curricula to where the high schools leave off. In any event, this situation elicits the observation that a part of the engineering manpower problem begins at the high school level.

2) The mortality rate in our engineering schools remains fairly high. It has been estimated that about 35 percent of entering high school freshmen graduate in four years, and about 40 to 45 of entering engineering freshmen eventually graduate. There are a number of factors associated with this problem, but two should be mentioned here: (a) As compared with prewar patterns, there appears to be a much larger number of students in the nominal four-year engineering curricula who take more than four years to graduate, this results in part from a lack of complete entrance prerequisites, in part from irregular programs due to the necessity of part-time employment, and in part due to the fact that many returning

2. Moyer, R. A., "Trends in the Numbers of Students Enrolled and Graduating in Civil Engineering, As a Factor in Providing the Additional Engineering Manpower Required in an Accelerated Highway Program in the United States," in Engineering Manpower in an Accelerated Highway Program, Special Report, I.T.T.E., University of California, Berkeley, California. March, 1955.

veterans felt they could not undertake a full-time study load. (b) There is some trend toward 5-year undergraduate engineering programs, either formally or informally laid out.

3) There is a discernible trend, at least in the accredited engineering schools, toward more broadly based undergraduate curricula, with less emphasis on specialization in the subdivisions of the major branches of engineering in the undergraduate years. Thus, in the future, in many undergraduate Civil Engineering curricula, we may expect to find greater emphasis on the sciences and engineering sciences, some increase in attention to the socio-humanistic studies, and fewer curricula in which a student will take a substantial number of undergraduate courses in a special field such as highway engineering. In a number of schools this means that the professional specialization will come in a fifth and graduate year. It also means that some new and effective ways must be found to inform undergraduates of career opportunities in, say, highway engineering, if this field is to attract its share of graduates.

4) If the seeming trend toward less specialization in the undergraduate civil engineering curricula maintains and develops, there are several important implications, some of which are: (a) graduates will be less specifically trained in the skills such as surveying, drafting and routine computing than were graduates of former years, so that some provision should be made for post-graduate, on-the-job, internship or engineer-in-training programs; (b) it may be desirable to urge increased emphasis on the "co-operative" type of educational program, where a student begins as a sophomore to work with a particular organization during summer periods or for designated terms of the school years.

5) Information assembled by the National Manpower Council[3] indicates that the ratio of supporting technicians to professionals is considerably lower in engineering than in other professions such as medicine. The valuable time of a physician is devoted to the actual use of medical skill and judgment; other functions are performed by nurses and laboratory technicians. One of the difficulties we encounter in engineering is a lack of a clear distinction between the purely technical and the purely professional—and perhaps this is where some heavy thinking needs to be done. At any rate, the key to this situation on a practical basis may have to be job analysis and job reclassification procedure. Already in some departments, jobs such as draftsmen, delineators, computers, etc., are well established. Perhaps what needs to be done is to make them more highly valued vocations, with reasonable rewards for long and productive service. At any rate, when jobs of this kind are disentangled from the engineering professional ladder, personnel can be recruited from high schools or elsewhere, and trained through short-term, specialized courses. This kind of procedure offers great opportunities for increasing the output of a limited supply of

3. National Manpower Council, Proceedings of a Conference on the Utilization of Scientific and Professional Manpower, Columbia University Press, New York, N.Y. 1954.

experienced professional personnel. It was utilized very effectively early in World War II, in turning out a vast fleet of aircraft. If a definite trend develops in this direction—and there are some indications that it may—members of the Civil and Highway Engineering profession may well begin thinking how the resources of technical institutes, junior colleges and other institutions may be mobilized so that vocational type personnel may be trained for and oriented toward careers associated with highway transportation service.

CONCLUDING COMMENT

The increasing tempo of highway development, and the prospects of still further increase in the years ahead, highlights the problem of manpower required to perform highway engineering functions. It is unlikely that the demands can be fully met by recruitment of additional, experienced, professional highway engineers or by new engineering graduates, whose numbers will remain inadequate for at least the next few years.

No single course of action, no one personnel or methodological change is likely to solve our manpower problems. Nor is a single unique educational policy likely to emerge. But many procedures are being developed, and we can be confident that they will include the basis for the handling of increased highway programs. We do need, however, to recognize the many facets and interrelated factors in this manpower problem, and to have a reasonable meeting of minds on the objectives to be pursued.

TABLE 1 -- COLLEGE AND ENGINEERING ENROLLMENT
FOR SELECTED YEARS, IN U.S.A.

Source: Journal of Engineering Education, based on U.S. Office of Education and A.S.E.E. joint survey data.

Years	Total College Enroll.[a]	Total Engg. Enrollment[a]		Undergrad. Engg. Enrollment	No. of First Degrees in Engg.[c]
		Number	% of Total College		
1940	1,490,000	113,497	7.6	108,911	11,358
1947	2,333,000	244,390	10.5	230,180	18,592
1948	2,410,000	241,554	10.0	226,117	27,460
1949	2,456,000	198,266[b]	8.0	180,646	41,793
1950	2,297,000	161,324[b]	7.0	142,954	48,160
1951	2,116,000	147,694[b]	7.0	128,367	37,904
1952	2,148,000	158,518[b]	7.4	138,170	27,155
1953	2,251,000	171,832[b]	7.6	150,426	21,642
1954	2,499,750	187,454[b]	7.5	167,103	19,707

[a]Includes graduate and undergraduate enrollment

[b]Includes only ECPD accredited institutions.

[c]For academic year; e.g. 1954 means academic year 1953-1954.

TABLE 2 — ENROLLMENT OF CE, EE, ME AND THE TOTAL FOR UNDERGRADUATE ENGINEERING STUDENTS AT ECPD ACCREDITED SCHOOLS IN UNITED STATES DURING THE FALL TERM FOR SELECTED YEARS, 1910-1954

Source: Journal of Engineering Education, based on U.S. Office of Education, E.C.P.D. and A.S.E.E. date

Year	Enrollment of undergraduate engineering students in E.C.P.D. accredited schools in United States during Fall term[a]						
	CE		EE		ME		All Eng.
	Number	%[b]	Number	%[b]	Number	%[b]	Number
1910	7,900	26	5,500	18	6,400	21	30,337
1920	8,800	17	9,300	18	11,900	23	51,908
1925	12,200	22	17,500	33	10,300	19	54,337
1930	13,813	19	18,500	25	15,000	20	73,386
1935	7,800	13	10,000	17	12,000	20	60,395
1940	11,152	10	15,500	14	28,600	26	108,911
1945	6,820	10	11,100	16	13,100	19	69,146
1947	29,609	13	52,292	22	53,459	23	230,180
1949	27,135	15	40,946	23	42,758	24	180,646
1951	19,744	15	24,564	19	27,134	21	128,367
1952	20,283	15	26,696	19	29,335	22	138,170
1953	20,882	14	30,916	21	31,390	21	150,426
1954	21,560	13	36,987	22	35,126	21	167,103

[a] Total number of E.C.P.D. Schools, 150 in 1954.

[b] Percent of all Engineering enrollments for given year.

TABLE 3 — ENROLLMENT OF CE UNDERGRADUATES AND OF ALL ENGINEERING UNDERGRADUATES AND THE NUMBER OF FIRST DEGREES GRANTED IN CIVIL ENGINEERING AND IN ALL BRANCHES OF ENGINEERING AT ECPD ACCREDITED SCHOOLS IN THE UNITED STATES FOR SELECTED YEARS, 1930-1954

Source: Journal of Engineering Education, based on U.S. Office of Education, E.C.P.D. and A.S.E.E. data.

	Undergraduate Enrollment			First Degrees Granted		
	Civil Engineers		Total all Engineers	Civil Engineers		All Engineers
Year	Number	%[a]	Number	Number	%[a]	Number
1930	13,813	19	73,386	1,977	24	8,303
1940	11,152	10	108,911	1,430	13	11,358
1947	29,609	13	230,180	2,692	14	18,592
1948	31,798	14	226,117	3,271	12	27,460
1949	27,135	15	180,646	6,119	15	41,793
1950	22,449	16	142,954	7,312	15	48,160
1951	19,744	15	128,367	6,473	17	37,904
1952	20,283	15	138,170	4,917	18	27,155
1953	20,882	14	150,426	4,070	19	21,642
1954	21,560	13	167,103	3,597	18	19,707

[a] Percent of all engineers in category for given year.

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DISCUSSION
(Proc. Paper 985)

Note: Paper 985 is part of the copyrighted Journal of the Highway Division of the American Society of Civil Engineers, Vol. 82, No. HW 2, May, 1956.

Discussion of
THE HIGHWAY SPIRAL FOR COMBINING CURVES OF DIFFERENT RADII

by Paul Hartman
(Proc. Paper 703)

C. C. WILEY,[1] M. ASCE.—This paper is very disappointing. It fails to prove its contentions and its derivations are in error while the ponderous formulas are far more likely to discourage rather than promote the adequate use of spirals.

The principle of the osculating circle is a basic geometric characteristic of the spiral derived directly from its definition. It is not a "theory" based on any sort of assumptions. Consequently it is precise and universally applicable. Small discrepancies that may appear in computations are the result of minute approximations in the derivations of certain formulas while larger differences are the result of incorrect assumptions in applying the principle.

At any point on the spiral the degree of curve of the osculating circle is a constant while the degree of curve of the spiral changes at a rate that is the same throughout the length of the spiral. Therefore, the geometric relation between the spiral and each osculating circle is exactly the same. It is evident that general formulas expressing this relation would involve factors from both the osculating circle and the spiral.

The limit of the osculating circle is the initial point (TS) where the degree of curve becomes zero whence the radius is infinity and the osculating circle becomes a straight line which is the initial tangent. With D = 0 the circular factors drop out and formulas expressing the relation of the spiral to the initial tangent become simple and easy to derive. At any other point than the TS the same formulas express the relation between the spiral and the osculating circle at that point. Therefore, all that is required to transpose the formulas from the initial tangent to any location is to add the proper factors from the given osculating circle. This appears most clearly in the formulas for deflection angles.

It has long been known that a deflection angle for a simple spiral is not exactly 1/3 of the change of direction, hence

$$\phi = 1/3\,\theta - C_a$$

Investigations of C_a show that it is normally so small it can be omitted and even if of some magnitude, as occasionally found, the ultimate effect on the actual location of the spiral is of such nature as to be insignificant. Consequently, the common practice is to omit it except in extreme cases. Mathematicians have habitually left the formula for C_a sort of dangling in the air without attempting to reduce it to practical form. The expression can be reduced to a form so simple it can be computed in one setting on a slide rule with all necessary accuracy.

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The deflection angles for a compound spiral are merely the deflection angles for a setup at a point on the spiral. Consequently, the formulas should be applicable to any point and any distance without being hampered by the "local conditions" of a specific problem, as is the case in the paper under discussion. The principle of the osculating circle shows that the deflection angle at any point is equal to the deflection angle of the osculating angle for the required distance plus, or minus according to direction, the deflection angle of the simple spiral for the same distance. Since the circular deflection is mathematically correct, the only error is C_a as given in the preceding paragraph.

More than 50 years ago a study was made of the foregoing by two independent methods, one analogous to that in 703 and the other entirely different. The combined effect was to show that

$$\phi_a = \phi_c \pm (1/3\,\theta - C_a)$$

subject to very small discrepancies traceable to minute approximations in the formulas for some of the component factors, and that C_a was as given above. This verified the correctness of C_a and verified the truth of the principle of the osculating circle.

Tables I and II conflict with the foregoing on two counts. First, the final values of C_a in both directions is just 10 times (3.75 vs 0.38 min) the value given by the older formulas that have stood the tests of time and thousands of applications. Second, the intermediate corrections are not the same in both directions.

Perhaps the first difference results from a misplaced decimal point somewhere. The second is more difficult to explain but suspicion suggests that somewhere in the exceedingly voluminous and unnecessarily complex mode of attack some mistake was made.

It is hardly within the scope hereof to discuss the mode of operation but it may be permissible to include a few comments. The rate of change of the degree of curve of the spiral is the parameter that fixes the spiral hence is constant for a given spiral. Had it been used throughout in conjunction with the distances, the complicating term, K, omitted, and the extra work of reducing other factors all to angles discarded, the derivations would have been simpler and the final formulas both simpler and applicable to any point and any distance. For a particular problem L_a would be merely a specific case of <u>1</u> and "abbreviated spirals" a myth.

The derivation of C_b is entirely wrong, apparently because of a basic misapplication of the geometry of the problem with consequent incorrect procedures. The specific item that causes the trouble is the <u>false assumption</u> that $\alpha + \beta = \Delta_1 + \Delta_2$. This equality is the conventional <u>approximation</u> commonly used in practice and is not the basic geometric fact involved.

The problem is to determine the effect of a spiral on a proposed layout, not the effect of an assumed layout on a spiral. The <u>spiral</u> is a fixed item. Its proper position is with its offset, CD, on the line of compounding as designated by the general curve plan. The position of CD within the spiral is fixed by arc CB = $1/2L_a$, which establishes the position of B with respect to the line of compounding. Therefore, $\beta = \Delta_2$ is a condition precedent to the correct solution of the problem.

At the other end of the spiral, AB is the distance of the CS, where D_1 joins it, from the line of compounding and is equal to $1/2L_a - C_t$ where C_t is the

familiar "tangent correction," of the simple spiral which now, under the principle of the osculating circle is to be measured on the D_1 circle. Reducing C_t to a central angle of D_1 gives an angular correction C_α to be added to the central angle of D_1 and subtracted from Δ_1 to give α. This is the only correction involved. Therefore, the complete and correct solution of the whole problem is contained in this paragraph.

C_p is a false byproduct of the incorrect derivation of C_b hence does not exist. The offset p is purely a function of the spiral. It is used in computing the tangent distances of the entire spiraled curve between the primary tangents, hence any distortion would affect the whole layout.

The example of a 400 ft spiral connecting a 10^o circle with a 20^o gives C_b as practically 10 min. Reducing this to arcs of D_1 and D_2 the distances are 1.66 ft and 0.83 ft. The effects are that A is moved forward 1.66 ft to 198.34 ft from D while B is moved forward only 0.83 ft to maintain the correct length of spiral. The result is that the spiral as a whole is moved forward and the offset is 0.83 ft from the established line of compounding. The direct solution of C_t from its own formula gives 0.82 ft. Thus the correct position of A is 199.18 from D which puts the offset on the line of compounding and leaves B at the proper distance of 200.00 from C. C_t reduced to central of D_1 is 4.7 min, or somewhat less than half of C_b. $C_p = -0.14$ simply does not exist since the spiral requires p to be 11.58 as quoted.

The suggestions concerning running half of a compound spiral from each end are not good. The point A is located from D_1 and B from D_2, therefore, each is subject to the field errors of the surveys leading up to it. If half of the spiral is run from each then the combined field errors, or the total for the whole layout would be concentrated at the middle of the spiral where it is difficult and undesirable to adjust them because of the changing curvature. The spiral should be run entirely from one end which will concentrate the errors at a junction with a circle and the errors can easily be run out on the circle easily and at a uniform rate.

As a whole, the situation is largely "a tempest in a teacup." In the vast majority of cases the "errors" are so small as to be negligible. Even when of some apparent magnitude the overall effects are peculiarly insignificant. Small longitudinal changes have no effect on the lateral placement and in themselves the worst they can do is show up in the field errors of closure. Small errors in deflection angle are corrected for direction in the orientation at the new setup, hence the worst they can do is to cause a small lateral displacement of the circular curve which usually would be lost in the normal field errors of the whole survey.

The obviously cumbersome and complicated formulas would be discouraging and disheartening to a would-be user and offer no inducement for their use. A person with some spiral experience would probably throw them aside because they are not in practical, workable form, even if they were correct. They have been carried to more terms than are reasonable and left hanging there. It is an author's duty to put things into attractive, and usable shape. If he does not his salesmanship is poor.

A. H. BROWNFIELD,[1] A.M. ASCE.—The writer found this paper very interesting although he has not had an active acquaintance with the subject for nearly twenty years. The authors synopsis appears to be correct. No direct attempt has been made to check his equations.

The purpose of this discussion is to place on record, additional data for those who may have need for it. It is not intended to discuss the present day use of spirals or their desirable properties but to present factual data for the computer who wishes to lay out a true spiral. This frequently saves time in checking, removes doubt from field closures and is a good source of personal satisfaction.

This problem has been treated by others; (1) on page 7 of "The Transition Curve" by C. L. Crandell, copyright 1903 and published by John Wiley & Sons. (2) In a longhand paper by D. E. Hughes compiled between 1937 & 1940, a copy of which was filed with the A.S.C.E. Engineering Library in N. Y. (3) In paper No. 2286 Trans. A.S.C.E. 111, 1946 pages 986 et seq., the writer indicated a reasonably exact method of traversing the Euler Spiral and this can be used for checking the authors graphs when R_2 becomes unusually short. ($D_2 = 20^{\circ}$ based on a 100 foot arc.)

In Mr. Crandall's book a general expression was developed for $\tan \phi_a$ using the rectangular system of coordinates. Several tables are presented for obtaining correct deflection angles at specific points along the spiral.

Mr. Hughes derived a rigorous solution for the particular case; given R_1, R_2 and p_a. This imposes two conditions, namely $p_a > 0$ and $R_1 > R_2$. He derived θ_2 from a series based on $\Gamma = \frac{R_1}{R_2}$. The use of this series is tedious, so he developed a correction table based on $R_1 S_1 = R_2 S_2 = K$ for each particular spiral and the other argument being the trial arc length. (Using the first term of θ_3 see Eq. (30).)

While working on the alignment for rails on the San Francisco Oakland Bay Bridge (1937) the writer found only one type of spiral problem that did not lend itself to a reasonably exact solution and that is the problem indicated above in the preceding paragraph. For this case a fairly accurate solution was developed based on

$$R_3 = \frac{R_1 \; R_2}{R_1 - R_2} \qquad (29)$$

$$\text{Let } n = \frac{6\, p_a}{R_3} \text{ then } \theta_3 = \sqrt{n + \frac{n^2}{28} + \frac{29n^3}{16170} + \frac{1391n^4}{13582800} +} \qquad (30)$$

This material was not submitted for publication in 1946 because (a) it is not exact, (b) it is needed only for the solution of the particular problem noted, (c) the table by Mr. Hughes was available. This type of solution is pertinent to Mr. Paul Hartman's original paper since it is not clear how he would solve this particular case. If an arc length La is taken as 400' (see Table 1) then the curve can be rigorously computed using Equations (56a),(56b),(56c),(58), (59a),(59b) and (60) as published in paper No. 2286 in conjunction with any one of several published tables of spiral functions. The deflection angles can then be computed using the authors methods or by traversing the spiral. Note there is a change in subscript for the radii between the authors paper and No. 2286.

Now to illustrate the problem. Given $p_a = 11.444'$. $R_1 = 572.958'$ and $R_2 = 286.479'$. What is the length of an Euler spiral arc required to join them? We should qualify p_a here by saying it is the least value p_a for the particular curve and given radii, all other values will be greater. Also this

example does not fit the usual spiral tables since it involves short radii and large angles.

Using Eq. (29) $R_3 = 572.958$ and by Eq. (30) $\theta_3 = 0.3469255$ (radian)

$$L_a = L_2 - L_1 = 2\,R_3\theta_3 \tag{31}$$

$$L_2 - L_1 = 397.547'$$

This is an approximate length and is always short since Equation (30) was derived for a spiral starting at the origin. For the more usual problem this first computed value of L_a will be sufficiently accurate.

$$L_2 = \frac{R_1 L_a}{R_1 - R_2} = 795.094' \tag{32}$$

$$L_1 = \frac{R_2 L_a}{R_1 - R_2} = 397.547' \tag{33}$$

$$L_2 - L_1 = 2 R_3 \theta_3 = 2 R_c \theta_c \tag{34}$$

$$R_c = \frac{R_1 R_2}{R_1 + R_2} \tag{35}$$

from this $\quad R_c = 190.986' \quad \theta_3 = 19.877^o$

$$\theta_c = \frac{R_3}{R_6}\,\theta_3 = 59.632^o \tag{36}$$

The total spiral angle $= \theta_3 + \theta_c = 79.509^o$. Now this can be corrected by trial and error, by Mr. Hughes' table or by the author's graph. $\theta_a = 19.9^o$ $\Delta_2 = 39.75^o$ $C_p = .355 \times .397547 = 0.141'$ the correct $p_a = 11.444 + 0.141 = 11.585'$. If this value is substituted in Eq. (30) $L_a = 400'$ and $\theta_3 = 20^o$.

The traversing of the spiral in Table 1 is quite simple and accurate as will be demonstrated. The computer should be equipped with a calculating machine, a slide rule, Barlow's table of squares, J. Peters 7 place trig. functions to 0.001 degrees. The computer should also be familiar with the fact that for a column of numbers such as $k\theta^2$, that the second differences are constant for equal intervals of θ. This will enable one to set up the traverse by addition. (The θ values and α_c.)

By Eq. (61a) of paper No. 2286

$$C_c = 4\,R_c \operatorname{Sin}\frac{\theta_c}{2} \tag{37}$$

where C_c is the chord length for a short piece of arc.

$$C_c = L_a - L_a\frac{\theta_c{}^2}{24} \tag{38}$$

L_a for Table 1 = 40 feet and the correction to L_a is

$$-L_a\frac{\theta_c{}^2}{24} = \frac{-40}{24}(\theta_c{}^o)^2\left(\frac{\pi}{180}\right)^2 = -.0005077\;(\theta_c{}^o)^2$$

$$\alpha_c = \frac{\theta_1 + \sqrt{\theta_1\theta_2} + \theta_2}{3} = \frac{\theta_1 + 4\,\theta_m + \theta_2}{6} = \text{chord slope} \tag{39}$$

θ_m is the total spiral angle at the mid arc point.

$$L_m = \frac{L1 + L2}{2} = 4 R_c \theta_m \qquad (40)$$

The sines and cosines were used directly from the tables and will not be included in the traverse.

Now for the particular spiral

$D_1 = 10^o$	$D_2 = 20^o$
$R_1 = 572.958$	$R_2 = 286.479$
$\theta_1 = 20^o$	$\theta_2 = 80^o$
$X_1 = 395.154$	$X_2 = 657.496$
$Y_1 = 46.139$	$Y_2 = 323.597$
$S_1 = 400'$	$S_2 = 800'$

Now from traverse

$$\tan \alpha_c = \frac{Y_2 - Y_1}{X_2 - X_1} = \frac{277.459}{262.341} = 1.057\,6273$$

$$\alpha_c = 46^o\ 36'\ 15''$$
$$\theta_1 = \underline{20^o}$$
$$\phi_a = 26^o\ 36'\ 15''$$ This value checks Table 1

Eq. 39 will give nearly correct values for α_c up to $L_a = 200'$ for this particular spiral.

Spiral Traverse—Table 1 703-9

Sta.	θ_s^o	θ_c^o	Chord Correction	Chord	α_c^o	X	Y
						657.496	323.597
14 + 00	80.0°					657.495	323.598
		7.8°	0.031'	39.969	76.067		
13 + 60	72.2					647.871	284.805
		7.4	0.028	39.972	68.467		
13 + 20	64.8					633.199	247.623
		7.0	0.025	39.975	61.267		
12 + 80	57.8					613.982	212.570
		6.6	0.022	39.978	54.467		
12 + 40	51.2					590.748	180.037
		6.2	0.020	39.980	48.067		
12 + 00	45.0					564.031	150.294
		5.8	0.017	39.983	42.067		
11 + 60	39.2					534.349	123.506
		5.4	0.015	39.985	36.467		
11 + 20	33.8					502.193	99.740
		5.0	0.013	39.987	31.267		
10 + 80	28.8					468.014	78.986
		4.6	0.010	39.990	26.467		
10 + 40	24.2					432.215	61.163
		4.2°	0.009	39.991	22.067		
10 + 00	20.0					395.154	46.139
						X_1	Y_1

The starting value X_1 & Y_1 at Sta. 10 + 00 could have been any values. The closure is very good in this case, being 0.001' for both X_2 & Y_2. If a few Civil Engineers find this data useful, the writer will feel that he has been justified in assembling it.

PAUL HARTMAN,[1] M. ASCE.—Mr. Brownfield's able discussion is a valuable addition to the paper. The writer is particularly indebted to him for the completely independent traverse check of the spiral of Table 1; the work involved is extensive.

It is apparent that the complicated derivations of the paper have tended to obscure the simplicity of the method of spiral layout which it proposes. This method differs from that of the theory of the osculating circle only in the application of three corrections to elements of the compound spiral as computed according to the theory. The corrections are: 1) C_b, obtained from the graph of Fig. 3, which is added to Δ_2 and subtracted from Δ_1; 2) C_p, obtained from the graph of Fig. 4, which is subtracted from the offset p of the equivalent spiral to obtain p_a; and 3) C_a, obtained from the graph of Fig. 5, which is added to the nominal deflection angle to the far end of the spiral when the setup is on the sharper circular arc and subtracted when the setup is on the flatter circular arc. In each case the correction is obtained by entering the graph with the values of Δ_2 and θ_a.

No corrections need be applied to deflection angles to intermediate points on the spiral provided not more than half the length of the spiral is set from one end. To lay the spiral out from each end it is necessary to establish one end of the spiral from the other by tangent distance and offset or by deflection angle and long chord. Either set of values may be obtained by traverse along the radii of the compound spiral.

Mr. Brownfield discusses the solution of the particular case when R_1, R_2 and p_a are fixed. With R_1 and R_2 fixed, p_a is a function of L_a. The most practical solution would seem to be to assume various values of L_a and compute the corresponding values of p_a. A simple plot of L_a versus p_a would serve to determine L_a with any desired precision. However, it would seem more practical to fix L_a rather than p_a, and thus avoid using an odd value of L_a which would complicate computation and layout work.

Both Professors Hickerson and Wiley, in their discussions, contend that the error in location of the end point of a compound spiral laid out by conventional methods will be small and may be lumped with the field closure. They overlooked the fact that the spiral so laid out deviates from the correct spiral at a rate which varies approximately as the fifth power of the distance, measured along the arc, from the transit setup. The effect of this deviation on curvature may be significant.

The effect on curvature may be shown by comparing the correct spiral of Table 1 with a similar spiral laid out in accordance with the theory of the osculating circle. The deviations at the fifth, sixth, seventh, eighth, ninth, and tenth points are 0.01, 0.02, 0.06, 0.11, 0.22, and 0.40 feet, respectively. The difference in successive deviations is a direct measure of the difference in curvature of the two spirals.

The curvature of the nominal spiral in this case is approximately 21.3° at the point where it joins the 20° circular curve. This error would have been

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still larger if the twentieth points had been set. Such a layout defeats the purpose of the spiral by introducing a sudden change of curvature in what is intended to be an easement curve.

Professor Wiley criticized the idea of laying out the spiral from both ends because the field error would appear at the midpoint. However, since one end of the spiral is located with respect to the other end as indicated above, the field error should be small. The resulting curve would be a far better easement curve than the curve run in from one end only, using deflection angles obtained from the theory of the osculating circle.

This paper presents the only practical method for the precise layout of a compound spiral. The method is essentially that of the theory of the osculating circle. The difference lies in the computation and application of corrections, a procedure which will not increase the time required for computation by more than ten minutes. The extra time is well spent as it gives meaning to field closures and results in a proper easement curve.

Discussion of "FLOOD-EROSION PROTECTION FOR HIGHWAY FILLS"

by C. J. Posey
(Proc. Paper 783)

CARL E. KINDSVATER,[1] M. ASCE.—Highway embankments in valley regions are inundated when flood discharges exceed the combined, normal capacities of bridge and culvert waterways. Such an occurrence may be an unexpected disaster, or it may have been anticipated in the design of the highway.

In those sections of the country where highways are required to cross many miles of flood plain or extensive swamp areas, planned inundation under some circumstances is an economic necessity. This is especially true for roads which are of less than primary importance in the transportation system. The savings which make such a plan economically feasible usually result from lower embankments, shorter bridges, and smaller or fewer culverts. Tending to offset the savings, however, is the cost of preventing or repairing the damage due to submergence and overflow.

Professor Posey describes a method of preventing damage to highway embankments which are subject to inundation by flood waters. His conclusions, based on original research and analysis, show the advantages of a blanket of "rock sausages" as a protective device. His report, therefore, is a contribution to highway design as well as to highway maintenance practices.

In his research the author was specifically concerned with the comparison of different methods of preventing flood damage to a typical highway embankment under representative conditions of submergence and overflow. It was logically beyond the scope of his investigation to study the hydraulics of overflow. Nevertheless, a complete understanding of the requirements for adequate protection will ultimately involve the discharge characteristics of the embankment. This appears to be an appropriate occasion, therefore, to add to the author's excellent report some comments regarding the flow of water over highway embankments.

Intermittently since 1947 the writer has been engaged in a study of embankment hydraulics. His interest began when the State Highway Department of Georgia sponsored an exploratory hydraulic model study under his direction in the Hydraulics Laboratory of the Georgia Institute of Technology. The study was subsequently continued as a special research project by several graduate students. It was recently the subject of a Masters thesis[2] which was sponsored by the ASCE's J. Waldo Smith Hydraulic Fellowship. It is currently the subject of research for a second thesis which is partly supported by the U. S. Geological Survey.

The experimental phase of the Georgia Tech research has so far been concerned with the overflow characteristics of a single form of embankment.

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2. "Discharge Characteristics of an Embankment-Shaped Weir," by Gunnar Sigurdsson, Georgia Institute of Technology, 1956.

Tests covering a full range of normal flow conditions have been conducted on several two-dimensional models, all having the shape shown on Fig. 1. The information collected includes surface profiles, velocity-distribution measurements, and discharge calibrations. The current investigation is mainly concerned with the internal mechanics of the flow pattern, including the character and influence of the boundary layer. The following comments, however, emphasize the external characteristics of the flow pattern. It is believed that it is this knowledge which is most essential to a better understanding of the requirements for embankment protection.

As an overflow structure, the highway embankment is a form of broad-crested weir. Depending on the boundary configuration, the rate of flow, the roughness of the surface, and the relative height of the tailwater, the discharge over an embankment may be described as either "free or "submerged" flow, or "plunging" or "surface" flow. Doubtless the most important classification is that which divides free flow from submerged flow. Free flow occurs when the embankment acts as a discharge control section. This condition is associated with low tailwater levels. Submerged flow occurs when the discharge is controlled by the tailwater level. This condition, obviously, is associated with high tailwater levels. The transition regime between free and submerged flow has been described as "incipient submergence."

Plunging and surface flow are most significant as sub-classifications of free flow. Plunging flow occurs when the discharge over the downstream shoulder continues to follow the surface of the embankment, thus "plunging" under the tailwater. Surface flow occurs when the discharge over the downstream shoulder separates from the lower boundary and rides over the surface of the tailwater. In general, plunging flows occur when the tailwater level is low; surface flows occur at higher tailwater levels. Thus, submerged flows are also surface flows.

It was first demonstrated during the exploratory tests at Georgia Tech in 1947 that the transition from plunging flow to surface flow, and vice versa, occurs within a well-defined range of tailwater levels. It was also demonstrated that the tailwater level at which the transition occurs is critically related to the history of the overflow. In other words, if the flow is initially plunging and the tailwater is low, the plunging flow pattern will persist as the tailwater level rises to an "upper limit" before changing suddenly to surface flow. This sequence of events would normally occur during a rising flood stage. On the other hand, if the tailwater is initially high and the high-velocity jet is on the surface of the tailwater, this condition will persist as the tailwater level drops to a "lower limit" before changing to plunging flow. This sequence of events would normally occur during a falling flood stage. The stability or persistence of the flow patterns within the transition range of tailwater levels is related to the inertia of the large, horizontal-axis rollers which occur downstream from the embankment and which are indicated on Fig. 2. It is significant to observe that the transition range marks the limits within which equal total energy losses result from either of the two stable flow patterns.

Fig. 2 shows photographs and Fig. 3 shows measured water-surface profiles for typical 1:6-scale model tests illustrating the various flow regimes described above. The transition range within which free discharge can be either plunging flow or surface flow is identified on Fig. 3 by the profiles marked (c), which is the upper limit, and (d), which is the lower limit. The

remaining profiles are (a) submerged flow, (b) incipient submergence, and (e) free, plunging flow.

Fig. 4 shows data obtained from the same series of tests which show the transition range in terms of the tailwater ratio, t/h. On the basis of these tests, which were among the first completed at Georgia Tech, it was concluded that the upper limit of the transition range could be predicted with good accuracy. It was recognized, of course, that the limits of the range might be influenced by the shape of the embankment. It was also reasoned that the flow separation which occurs at the downstream edge of the downstream shoulder during surface flows could be stimulated by artificial means. The result would be to lower the upper limit of the transition range and thereby extend the range of tailwater levels in which the occurrence of surface flow would be assured. The practical significance of this reasoning was related to the assumption that surface flows are less erosive than plunging flows. From the results of his own research, Professor Posey has doubtless formed an opinion regarding the correctness of this assumption.

The extent to which very slight variations in boundary characteristics would influence the tailwater limits of the transition range was revealed by subsequent experiments on other models. For various reasons, the Georgia Tech experiments have involved three embankment models, each built to a different scale (1:6,1:9, and 1:12) but all built to simulate the cross-section shown in Fig. 1. In addition, several degrees of boundary roughness have been involved. It was soon apparent that each model and every modification of each model could be characterized by distinctive variations of the curves shown on Fig. 4. The curves obtained from each test series were well-defined, but there was no reasonable correlation between the results of the tests and the differences in the models.

The extreme sensitivity of this relationship to the shape of the downstream shoulder was finally demonstrated by a special series of tests on the 1:9-scale model. In these tests a wire of 0.09 in. diameter was fastened to the downstream edge of the shoulder. As a result, values of t/h corresponding to the upper and lower tailwater limits were changed an average of 15 percent. It is understandable, therefore, that the different models failed to define a single characteristic relationship of the kind shown on Fig. 4. It is also apparent that the flow pattern downstream from inundated highways will be critically dependent on the configuration of the downstream shoulder. It should be emphasized, however, that the flow pattern upstream from this shoulder is unaffected by the causes of the transition phenomena. It follows that, because the control section is at or near the crown for all free-flow conditions, the head-discharge relationship is unaffected by minor variations in the shape of the downstream surfaces of the embankment.

The Georgia Tech studies have included an investigation of the discharge characteristics of submerged flow. It is significant that the results of the submergence tests on the different models were remarkably similar. It was revealed, for example, that the relative depth of tailwater required to produce incipient submergence is only slightly influenced by discharge, embankment height, and roughness. Thus, incipient submergence for practically all of the conditions investigated occurred when the height of the tailwater measured above the crown was about 0.85 times the head. In other words, the head-discharge relationship is unaffected by the tailwater until the ratio t/h exceeds about 0.85. And, unlike the transition from plunging to surface flow, the

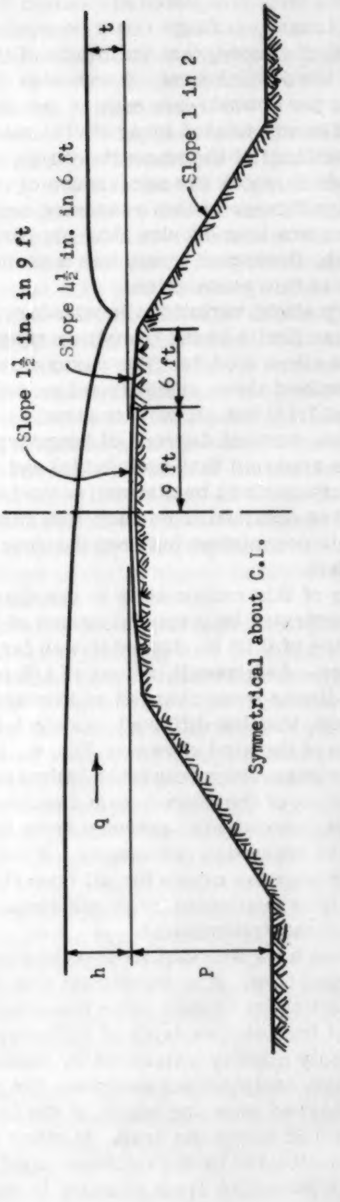

Fig. 1.--Embankment Section Investigated at Georgia Tech.

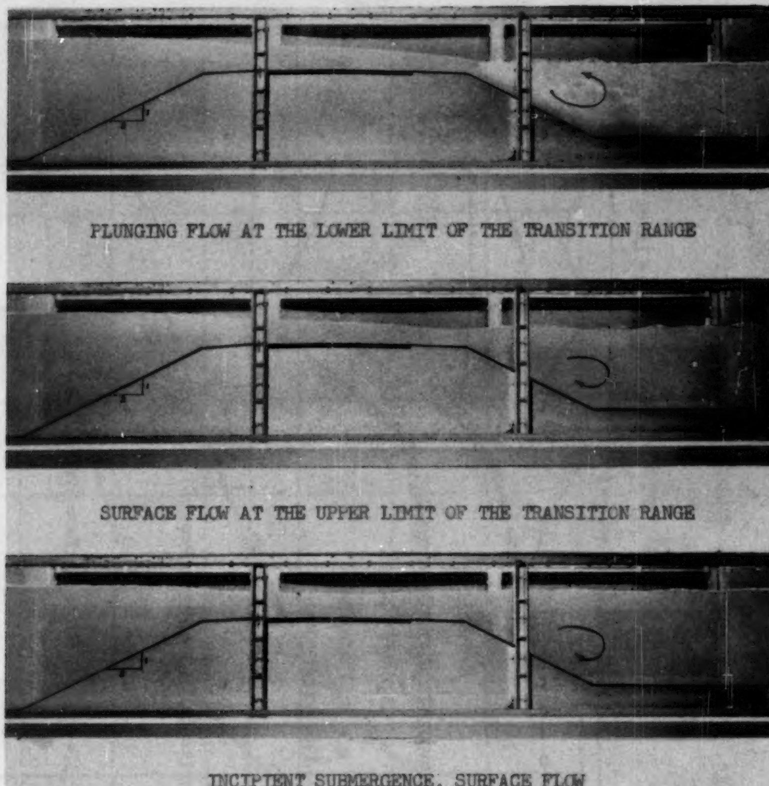

Fig. 2.--Influence of the Tailwater Level on the Flow Pattern.

transition from free to submerged flow occurs at the same value of t/h for both the rising and falling sequences of tailwater variation.

Under "Some Possible Ways of Improving the Modern Type of Valley Crossing," Professor Posey suggests that in some locations bridge openings can be made large enough to pass the largest floods without causing the upstream water level to exceed the level of the adjacent embankments. This, of course, presumes adequate knowledge of the hydraulics of bridge waterways—knowledge which was largely non-existent until a few years ago.

A comprehensive research program on the hydraulics of bridge openings was begun in 1951 by the U. S. Geological Survey (Surface-water Branch, Water Resources Division) under the writer's direction. As a result, several

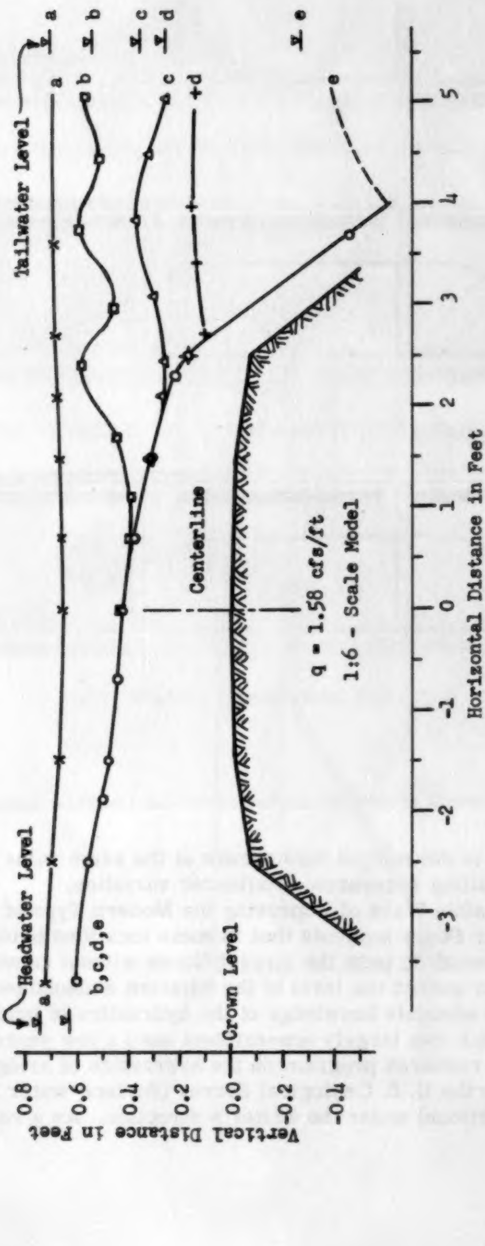

Fig. 3.--Typical Water-Surface Profiles.

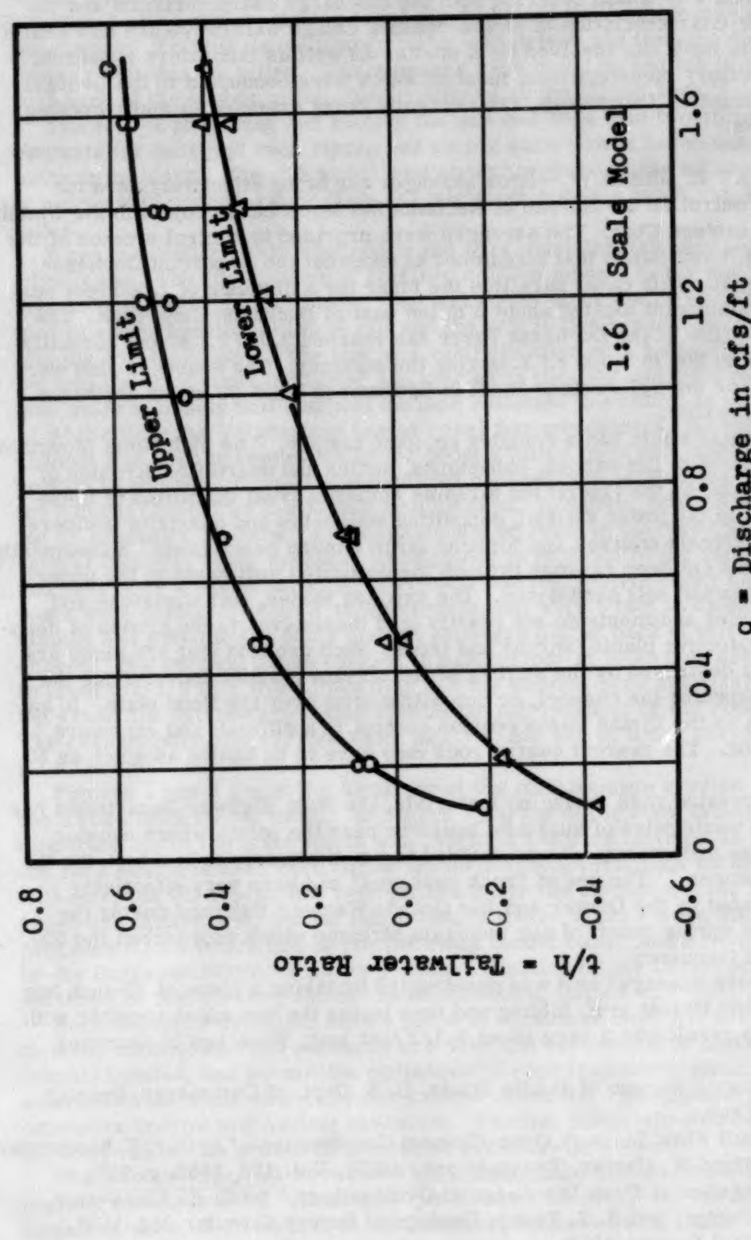

Fig. 4.--Tailwater Limits of Transition Range

publications[3,4,5] which describe both the discharge characteristics and the backwater characteristics of single-opening bridge waterways are now available. This work has involved field studies as well as laboratory research. The laboratory investigations, most of which were conducted in the Georgia Tech Hydraulics Laboratory, are currently being extended to multi-opening waterways.

PARLEY R. NEELEY*.—Rock sausages are being effectively used for erosion control on the Bureau of Reclamation Moon Lake project in the Uintah Basin of eastern Utah. The sausages were provided to control erosion of the Duchesne River Banks that threatened to undercut the important Duchesne feeder canal. This canal parallels the river for a distance of 1,500 feet near the diversion point located about 6 miles east of Duchesne City, Utah. The peak flood flow of the Duchesne River has reached 9,000 c.f.s. and normally ranges from 200 to 1,000 c.f.s. during the summer. The sausages also were provided for the Yellowstone canal in Cottonwood Wash 20 miles northeast of Duchesne City.

The Uintah Basin has a complex geologic history. The high Uinta Mountains are composed of limestones, sandstones, shales and quartzite. Erosion of the formation by the glacial fed streams removed great quantities of these materials to the lower valleys, depositing sediments and quartzite boulders along the stream courses and forming large sloping bench lands. Subsequently the streams cut deep canyons through the deposited sediments to the underlying shales and soft sandstones. The exposed shales, soft sandstone and shale-formed sediments do not readily lend themselves to the growth of deep-rooted protective plants, shrubs and trees. Such growths that are made are frequently destroyed by the shifting of the stream channel undercutting the banks, deepening the channel, or depositing silts over the flood plain. In an area such as the Uintah Basin erosion control is a difficult and expensive undertaking. The nearest quarry rock may have to be hauled as much as 50 miles.

In processing road surfacing materials, the State Highway Department has left large waste piles of quartzite boulders near the points where erosion control was undertaken. It was decided to use the quartzite boulders for the "rock sausages." The use of "rock sausages" had been very effectively demonstrated by the Denver and Rio Grande Western Railroad during the 1952 early spring runoff of our mountain streams which approached the 50-year flood frequency.

The "rock sausage" unit was constructed by taking a piece of 32-inch hog wire fencing 10 feet long, folding and then lacing the two edges together with wire. The result was a cage about 3-1/2 feet long, 20 inches in diameter

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*Area Engr., Bureau of Public Roads, U. S. Dept. of Commerce, Spanish Fork, Utah.

3. "Tranquil Flow Through Open-Channel Constrictions," by Carl E. Kindsvater and Rolland W. Carter, Transactions, ASCE, Vol. 120, 1955, p. 955.
4. "Computation of Peak Discharge at Contractions," by C. E. Kindsvater, R. W. Carter, and H. J. Tracy, Geological Survey Circular 284, U. S. Geological Survey, 1953.
5. "Backwater Effects of Open-Channel Constrictions," by Hubert J. Tracy and Rolland W. Carter, Transactions, ASCE, Vol. 120, 1955, p. 993.

which, when standing up, had a closed bottom and open top. The wire cage was filled with cobbles, the top laced together, and the sausage was then ready for placing. Treated native timber piling was driven and timbers spiked horizontally between the piling. The sausages were stood on end for two tiers high back of the timber piling, then continued on the sloped bank.

The cost of preparing and placing the unit was less than two-thirds of the estimate for quarried rock riprap had such a quarry been in the near proximity of the work. The unit would cost about one-third of the estimated cost of riprap with quarried rock from the minimum distance available, about 50 miles.

When the cobbles were confined in the wire mesh the unit provided many advantages. The combination of confined cobbles made a heavy unit which acts as one large compact piece. The eddies set up by the irregular surface tend to encourage deposition of silt and the unit is flexible and settles snugly into the soft foundation. The unit was easily handled with a dragline by hooking into the wire mesh for lifting and placing in position and their uniform size made a closely knit compact surface resistant to erosion or shifting.

At the time the Yellowstone feeder canal was constructed, the natural channel was used to convey water for about 2 miles from one constructed portion to another. It was not considered necessary to protect the banks of the natural channel as it was in a remote area. However, erosion was causing an expensive operation and maintenance problem in the canal below the natural channel. Rock sausages were placed in portions of the natural channel and have done a remarkable job of erosion control. Native cedar (Juniper) posts were placed at about 8-foot intervals, hog wire 3 feet in height was stapled and wired to the posts and the sausages placed back of this wire screen. The vertical banks ranging in height from 15 to 40 feet were trimmed to about a 1-1/2 to 1 slope. Not only has the erosion been practically stopped but grass and willows are taking root in the silt retained by the rock sausage. The channel normally carries about 80 c.f.s. and has at times exceeded 100 c.f.s.

Figures 1 and 2 are at the locations of the rock sausage erosion control on the Yellowstone feeder canal. In Figure 1 the top of the rock sausages can be discerned above the trash which was caught in the wire netting. In Figure 2 the rock sausages have been buried under the slough from the banks. As you will note, the wire mesh has been pushed out in the stream and the rock sausages are immediately behind this mesh. Figures 3 and 4 were the work in progress on the protection of the Duchesne feeder canal banks from erosion by the Duchesne River. Figures 1-4 were supplied by the United States Department of the Interior, Bureau of Reclamation, Region 4.

Rock sausages definitely have a place in erosion control and are adaptable to many conditions. The sausages are easy and economical to make, can be readily handled, and permit the utilization of rock fragments usually found adjacent to the point where erosion control is needed without undertaking an expensive borrow and hauling operation. The fine materials retained between the rocks allow the growth of protective grasses and willows.

The Reclamation Era November 1955 issue, page 87, carried a discussion on rock sausages titled "'Sausages' for Erosion Control," by Parley R. Neeley, Area Engineer, U. S. Bureau of Reclamation, Spanish Fork, Utah.

Figure 1.

Figure 2.

Figure 3.

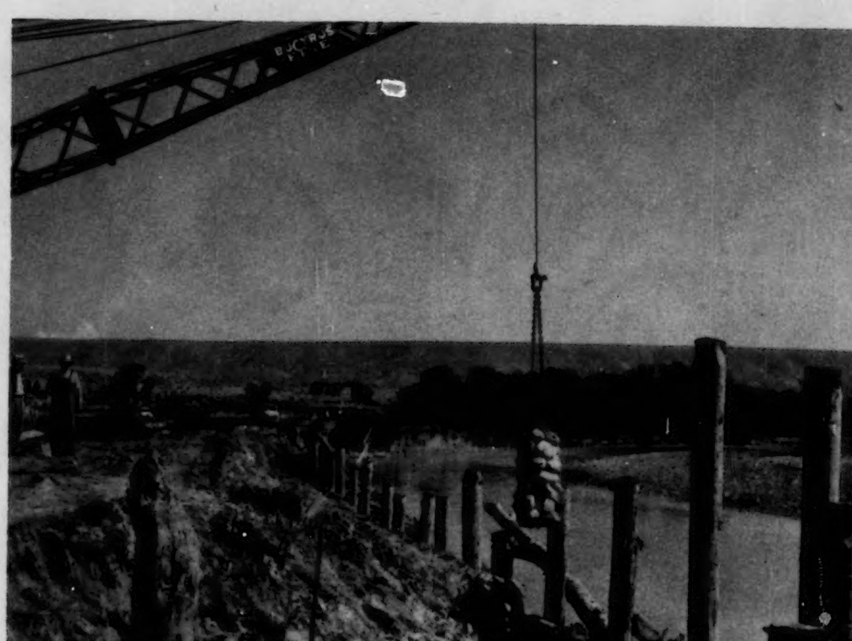

Figure 4.

Discussion of
"USING CONSULTANTS TO EXPAND A HIGHWAY PROGRAM"

by Rex M. Whitton
(Proc. Paper 824)

PECOS H. CALAHAN,[1] A.M. ASCE.—This paper is a critical analysis of the experience of one highway department in the use of consultants to expand its road and bridge program. The author has expressed his own opinions regarding the advantages and disadvantages of using consultants. It is gratifying to note that in spite of his seemingly firm belief that consultants should be used only as an expedient, he thinks highly enough of their services to close his paper with the recommendation that other highway departments make use of consultants to expand their programs.

The context of the paper is very specific in its relation to the experience of the Missouri State Highway Commission, but it is implied that the author's observations would apply equally well to other highway departments.

The reasons advanced by Mr. Whitton for using consultants are that the highway department program exceeds the capacity of the regular personnel and existing facilities, shortage of trained personnel, and inability of highway departments to meet the salary scales in a competitive market for technical help.

The only real disadvantage in using consultants, as claimed in the paper, is that their services are more expensive than regular highway department personnel. The other arguments given are merely elaborations of this one theme and are supported by figures which appear incongruous and by statements which need more data to be acceptable as facts. For instance, the average figure given for salaries would, in some sections of the country, be only slightly higher than starting salaries for college graduates.

One statement made is that consultants usually pay higher salaries than the highway departments and that it is necessary, therefore, to pay the higher salaries when consultants are employed. Assuming that a highway department desires to expand its forces with experienced men, its only source of technical help will be from consultants. It will be necessary, therefore, for the highway department to pay the same or higher salaries to wean them away from consultants. The cost of salaries, therefore, under an expanding highway program would be the same whether done by the highway department or by consultants.

Another statement implies that consultants require more time to produce a given drawing than do highway department personnel. Conversations with persons who have been employed by state highway departments and by consultants rather generally point out that efficiency, morale, incentive and quality of personnel under consultants are equal to or better than that under a highway

1. Exec. Secy., Cons. Engrs. Assn. of California, San Francisco, Calif. (Discussion prepared by a special committee and submitted by order of Board of Directors, Cons. Engrs. Assn. of Calif.)

department. It is probably true that a consultant's initial experience with the highway department may suffer in efficiency from unfamiliarity with standards and practices of that department but this should not be true in later assignments.

The paper states that when consultants are used, "You" (the highway department) necessarily are paying for their overhead and profit. This argument is a fallacy which is fallen into by many a government agency: the fallacy that the agency is paying the bill for the services rendered. From the standpoint of the taxpayer who is paying the bill, every item of overhead in a consultant's fee has a corresponding item of overhead in the highway department. It is very hard to determine the overhead charges in a highway department's operations because such figures are not usually assessed against the department and are not listed in their annual reports. A listing of some of the items may be enlightening in this regard, however. For instance, the highway department probably does not pay rent for all its facilities but it should assume a legitimate charge for maintenance and depreciation of the facilities it is using. The administrative expenses in conducting business must be assessed against the highway commission, its chief engineer and department heads. A highway department must have its accounting and purchasing departments, its clerical and stenographic help, its office supplies and equipment, its printing and duplicating departments, its telephone and telegraph expenses, its legal expenses, its depreciation on furniture and equipment and its library and periodicals. A highway department very often has unallocated salaries such as people working on standards or on proposed projects which in some cases are never built for political reasons, lack of funds, or changed programs. Highway departments have sick leave, vacation and holiday pay which in many cases are more liberal than is the practice with consultants. Further comparisons would merely demonstrate the similarity of costs under highway or consultant management.

This paper parallels somewhat Report No. 21 of the University of California Institute of Transportation and Traffic Engineering, a report prepared on the basis of questionnaires sent to all highway departments in the United States as well as to Federal agencies, to some private industries and to some consulting engineers. Report No. 21 has considerably more detailed information regarding the general arguments for and against the use of consultants, the amount and types of services rendered, selection of consultants and contracts and fees. A summary of Report No. 21 also appears in Highway Research Board Bulletin 106. According to Report No. 21, not all highway departments consider consultants more expensive; it states that 80 per cent believe the consultant's services cost more, 10 per cent believe the cost is less, and 10 per cent believe the costs are the same.

In an expanding program of highway work throughout the nation, the relative costs of performing the work will be sublimated to the prime objective of accomplishing the work quickly and efficiently. It would behoove the highway departments to prepare for such a program by building up a pool of consultant specialists on highway work.

A strong engineering profession is today an admitted necessity for national development and progress. The armed forces of the United States have assisted in this program by successfully augmenting their engineering staffs in times of war and peace by the use of consultants. Likewise, the highway departments of the country could do a great service to the public by making more use of consultants in their highway and bridge programs.

FRANCIS W. HOLDEN,[1] J.M. ASCE.—The paper by Mr. Rex M. Whitton on "Using Consultants to Expand a Highway Program" gives expediency as the reason for using consultants in an expanded highway program. The author further qualifies his remarks by explaining that the expediency was one of urgency brought on by an increased work load and an inability to enlarge the existing state highway design section sufficiently. Under such circumstances, Mr. Whitton is justified in advising other highway departments to employ consultants. Before the decision is made, however, all possibilities for enlarging the existing staff should be attempted.

The most obvious method of attracting sufficient qualified engineers is to raise salaries to a level equal to those paid by private concerns. Regular highway engineers are by reason of their specialized experience best qualified to perform the work and it is therefore the duty of public officials to see that these men do the work and are compensated accordingly. Too often, state engineers are required to subsidize a highway program by receiving inadequate salaries. The leadership in efforts to raise these salaries should be supplied by the responsible officials not only to properly serve the public, but also as a proper function of their administrative duty which implies an interest in the welfare of their subordinates.

If considerations prevent a general rise in the salary schedule for state engineers, an alternate could be found in enlarging the existing table of organization. With the creation of new positions at the top of the organization, senior men could be given the advancement to which they are entitled and thereby create vacancies in the lower grades which could be filled by junior men. Starting salaries in state and private service are more nearly comparable than in advanced grades so that less difficulty would be experienced in enlarging a department in this manner. Presently many senior designers are being held back by an organizational setup based on prewar requirements. The means for correcting the situation are within the power of the officials and before turning to consulting engineers these officials must in good conscience exhaust every possibility for enlarging their own forces.

Mr. Whitton has touched very lightly on the method of selection of consultants. It is in this respect that the greatest danger exists. Public monies are generally spent under lawful and open procedures which preclude the possibility of graft and corruption. Employees are selected on the basis of competitive Civil Service examinations, and other services procured by bids. In engaging consultants, however, competitive bidding is rightly banned and the only safeguard of public funds rests in the honesty and integrity of the official concerned. In view of the present charges of graft in Jersey City, it would seem that the present method is open to considerable improvement. Taken to the extreme, the situation in the hands of an unscrupulous official could lead to complete corruption including the reduction or elimination of present highway staffs who would be considered in competition with the favored few.

For the above reasons, Mr. Whitton's recommendation for the use of consultants to expand a highway program should be strongly qualified to include the provision that first every possibility for enlarging present staffs be explored and second that some system be provided to insure value received for public money spent.

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1. Asst. Structural Engr., State Dept. of Public Works, Worcester, Mass.

ROBERT H. GRIFFITHS,[1] J.M. ASCE.—After reading the article by Rex M. Whitton, it was felt that the experiences of consultants in another area should be added.

It is felt that some of the facts as experienced in Idaho are different from those experienced in Missouri.

Mr. Whitton states that consultants are more expensive than state forces. The usual basis of comparison between force account and contracted engineering is frequently unfair because two factors are frequently overlooked. The cost records normally kept on a project usually reflect the direct costs only and do not include many hidden items of overhead which are actually important items in arriving at a true total cost. Lost productive time of personnel is often a very important item and should include the time lost between jobs. The costs of main office supervision should be included whether the work is contracted or accomplished by own forces. Charges for office space, equipment, general supplies, taxes, insurance and other indirect costs should be included. Normally the jobs contracted to the private engineers are distress situations of one kind or another. This may be due to complexity of design, a very tight time schedule, or perhaps involved political considerations in routing.

In Idaho Consulting Engineers are more than an expedient. The Idaho Dept. of Highways does not provide the engineering on Federal Aid Secondary Routes which are not on the State System. These county roads are eligible for Federal Aid but are the responsibility of the County in which the road is located. However, the Dept. of Highways acts as the contracting agency on construction, the plans must be approved by the Dept. and the work is to Department specifications. The County reimburses the Department for all costs on the project. As a result the counties must look elsewhere for engineering to build these projects on the County Road System if these projects are to receive Federal Aid. The Counties do not have a sufficient volume of work to require the full-time services of an engineer and have turned to the use of consultants with satisfactory results.

In the County Road program there is a definite need for the Consultant because a single county does not have sufficient funds to retain a full-time engineer. In the State Road Program the consultants are able to supply special services such as photogrammetry, structural design, and urban studies for which the Department does not have the need to require the full-time services of a specialist in that field.

Mr. Whitton states that 600 miles of work have been contracted at a cost of about 2-1/2 million dollars. This exceeds $4,000 per mile average cost.

It would appear that most of this mileage involved urban or suburban projects which required a great deal of detail. Do the consultants handle the requisition of Right-of-Way?

One firm in Idaho has prepared plans and quantity estimate with 45 miles of roadway centerline staked in a primitive area which required the use of pack animals at a cost of $1650 per mile. This project required the use of photogrammetry for reconnaisance and establishing a projected location which was then established in the field.

Another project on a 20 mile section of a US marked route for a complete relocation required a photogrammetric control survey line, mapping of the

1. Staff Engr., Barton, Stoddard, Smith & Milhollin, Engrs., Boise, Idaho.

route and location of the centerline at a cost of $1500 per mile which included cross-sections, earth work quantities and contract plans.

The Dept. of Highways has contracted for plans, estimate and earthwork quantities for a 30 mile relocation of another US marked route in mountainous terrain at a cost of $1800 per mile.

On a proposed relocation of a 30 mile section of a US marked route through rolling agricultural land, the Dept. has contracted for a strip map prepared photogrammetrically. These maps were prepared to much higher standards and much cheaper than the Dept. could have done by using conventional methods.

Mr. Whitton mentions 90 to 200 man hours per sheet on bridge plans as compared to 30 to 100 man hours per sheet by State forces.

A consultant in Idaho has prepared plans and specifications for a 450 foot skewed, four-lane reinforced concrete continuous bridge at a cost of 74 man hours per sheet. This bridge was constructed at a cost of $300,000. The consultants fees did not exceed 4%.

Mr. Whitton mentions an average salary figure of $2.59 per hour. Idaho consultants are paying engineers in excess of $3.00 per hour and the State Highway Department is paying in excess of $500 per month. At least 50% of the time on the design and plans would have to be sub-professional at $2.00 per hour to achieve an average of $2.59 per hour. This figure should be increased to allow for taxes on salaries, insurance and office overhead charges.

It should be noted that supervising engineers are also assigned to work with State forces as well as with consultant forces.

A complete agreement as to what is expected of the consultant is an aid in reducing the number of projects where the undesirable "cost plus" is required.

[illegible]

The Dept. of Highways [illegible]

[illegible]

Discussion of
"ANALYSIS OF A SKEW DIVERSION"

by Wen-Hsiung Li
(Proc. Paper 868)

CORRECTIONS.—In publishing this paper the footnote references used by the author were inadvertently omitted. To assist readers, the footnotes are as follows:

1. Handbook of Culvert and Drainage Practice, Armco Drainage and Metal Products, Inc., Middletown, Ohio, 1950.

2. Tilton, G. A. and Rowe, R. R., "Culvert Design in California," Proc. Highway Research Board, Vol. 23, 1943.

3. Agg, T. R. and Carter, H. S., "Highway Transportation Costs," Bulletin No. 69, Iowa State College, 1924.

4. Barrows, H. K., Floods, Their Hydrology and Control, McGraw-Hill Book Co., 1948, p. 140.

DIVISION ACTIVITIES
HIGHWAY DIVISION
Proceedings of the American Society of Civil Engineers

NEWSLETTER

May, 1956

HIGHWAY DIVISION EXECUTIVE COMMITTEE

Emmett H. Karrer[1] (Chairman)	**Ohio State University** **Columbus, Ohio**
Harmer E. Davis[2] (Vice Chairman)	**Institute of Transportation and Traffic Engineering** **University of California** **Berkeley, California**
Bertram D. Tallamy	**N. Y. State Thruway Authority** **Albany, New York**
William A. McWilliams	**Charles M. Upham Associates** **Washington, D. C.**
Arch N. Carter	**Associated General Contractors of America, Inc.** **Washington, D. C.**
J. Paul Buckley (Secretary)	**Automotive Safety Foundation** **200 Ring Building** **1200 18th Street, N. W.** **Washington 6, D. C.**

Note: No. 1956-12 is part of the copyrighted Journal of the Highway Division of the American Society of Civil Engineers, Vol. 82, HW 2, May, 1956.

1. Appointed to fill unexpired term of Harold J. McKeever.
2. Appointed to fill unexpired term of George W. Deibler.

HIGHWAY DIVISION

May 7, 1956

The Highway Division has become increasingly active in promoting activities and dispersing information of interest to those members of the ASCE who are concerned with planning and design of highways.

The Executive Committee of the Division is to meet in Washington, D.C. on May 7, to discuss and take action on an extensive list of topics. Perhaps foremost will be action on behalf of the National Highway Program. Also to be considered are measures for making the Highway Division even more useful to its members.

As of January 1st, there were 2599 members enrolled in the Division.

JUNE MEETING

Knoxville, Tennessee, June 4-8, 1956

Professor E. A. Whitehurst, of the Committee on Session Programs, is making the arrangements for the Highway Division Sessions at the June Meeting of the Society to be held at the University of Tennessee in Knoxville. Professor Whitehurst is a member of the faculty of that University.

There are to be two Highway Division Sessions during the course of this meeting. Although the exact day and time of each of these sessions has not yet been determined, the plans for the programs have been established.

Dean N. W. Daugherty, of the School of Engineering at the University of Tennessee, will preside at the First Session. Speakers and subjects will be:

H. H. Hale, Assistant to Vice President, Association of American Railroads, "American Transportation—Mass in Motion."

W. M. Leech, Commissioner, Tennessee Department of Highways and Public Works, "Long Time Highway Studies."

A. E. Johnson, Executive Secretary, American Association of State Highway Officials, "The Case of the Interstate System of Highways."

W. F. Babcock, Professor of Civil Engineering, North Carolina State College, "Traffic Generation Characteristics and Thoroughfare Planning for Urban Areas."

The Second Session will be held jointly with the Surveying and Mapping Division. Mr. B. E. Beavin, Chairman of the Executive Committee of the Surveying and Mapping Division, will preside. Speakers and topics will be:

Paul Garber, Soils Engineer, Howard, Needles, Tammen and Bergendoff, "Field Control of Earthwork Construction."

T. L. Collins, President, Maps Incorporated, Baltimore, Maryland, "Developing Simultaneously an Aerial Map for Highway Design and Geological and Soil Interpretation."

These two papers will be followed by a panel discussion of the general topic "Surveying and Mapping for Modern Highways" with W. N. Calvert, Jr., Civil Engineer, TVA, as moderator. Four papers will be presented during the course of this panel discussion. They are:

D. K. Blythe, Assistant Professor of Civil Engineering, University of Kentucky, "Use of Aerial Surveying in Highway Location and Design."

Captain Charles Pierce, Chief, Division of Geodesy, U.S. Coast and Geodetic Survey, "Basic Control for Highway Mapping."

Colonel J. G. Ladd, USA Ret., Executive Secretary, Association of Professional Photogrammetrists, "What Aerial Mappers Can Contribute to Highway Planning and Location."

W. T. Pryor, Highway Engineer, Bureau of Public Roads, "Bureau of Public Roads Experience on Highway Surveys."

NATIONAL HIGHWAY PROGRAM

The Highway Division's Committee on Cooperation with Local Sections has been working jointly with a special ASCE Task Committee in stirring up interest among the local sections in an expanded federal highway program.

The Task Committee was authorized by the Board of Direction of the ASCE "to represent the Society in any way that may be appropriate and desirable in the furtherance of federal legislation relating to a National Highway Program." This Task Committee, together with the Committee on Cooperation with Local Sections, has asked all of the Society's local branches to hold special meetings on the subject of the National Highway Program and to bring to the attention of members of Congress and other appropriate officials, as well as the general public, the views of the Society.

As a result of the joint effort, many local sections throughout the nation have taken appropriate action. From information presently available, it has been determined that special meetings have been held by the following sections and branches: Alabama, Buffalo, Central Illinois, Colorado, Connecticut, Dayton, Ohio, Duluth, Forth Worth, Illinois, Kansas City, Maine, Metropolitan (New York), Michigan, Mid-South, Montana, Nashville, National Capital, North Carolina, Northeast, Oklahoma City, Philadelphia-Lehigh Valley, Rochester, San Francisco, and Tennessee Valley.

Montana won top honors in its local enthusiasm, holding local meetings in six cities in the state. Several of the sections passed resolutions which were forwarded to members of Congress. The Honorable R. F. Mack (Representative) had the resolution of the Central Illinois section entered in the Congressional Record.

These meetings were given good newspaper and radio coverage and were no doubt very helpful in giving Congressmen and Senators representing those areas a new and professional look at the highway program from the grass roots level. These sections and branches which sponsored the meetings are to be congratulated for their important work in behalf of better roads for America.

Bertram D. Tallamy, Chairman of the New York State Thruway Authority and Chairman of the special Task Committee, reports the following outlook for federal legislation.

"At this writing, the fate of Federal highway legislation during the current session of Congress is clouded by a number of controversial amendments to the Fallon bill.

As reported by the House Subcommittee on Roads to the full Committee on Public Works, the bill includes these amendments:

1) Permitting the Federal Government to determine prevailing wages to be paid on construction work on the Interstate System.

2) Freezing existing State limitations on truck weights and dimensions.

3) Payment by the Federal Government of half the cost of relocating public utilities in connection with construction of the Interstate System.

4) Federal guarantee of bonds issued by States or municipalities to build highways adjacent to but not included in the Interstate System.

5) A two-year study of extending credits to states for existing free and toll roads on the Interstate System.

With opinion sharply divided on many of these added features of the legislation, it would be foolhardy at this point to venture any predictions on the final outcome. Certainly this is not the time to be over-confident about its passage. If any Sections, Branches or Members of the Society have not given their representatives in Congress the benefit of their considered opinion as to the road situation in their area, they should do so promptly.

Such professionally responsible comments will be extremely helpful to the members of Congress in their consideration of this very important legislation."

Members of the special Task Committee are: B. D. Tallamy, Chairman, Arch N. Carter, Harmer E. Davis, Emmett H. Karrer and William Roy Glidden, Board Contact Member.

Members of the Division Committee on Cooperation with Local Sections are: S. E. Ridge, Chairman, W. F. Babcock, J. N. Clary, Ellis Danner, S. M. Rudder, J. L. Cheatham, Jr., John R. Dietz, W. A. Bugge, George L. Epps, Edward J. Nunan, John O. Morton and Curtis J. Hooper.

THE AASHO ROAD TEST

Arch Carter, Chairman of the Division Committee on Developments in Highway Engineering and Construction, has kept close contact with plans for the AASHO Road Test in Illinois. Through his assistance, a report on the origin and history of the AASHO Road Test has been received and is summarized herewith for the interest of Division members. The report was prepared by Fred Burggraf, Director of the Highway Research Board, and presented at the Forth-seventh Annual Meeting of the Mississippi Valley

Conference of State Highway Departments, Chicago, March 8-10.

The American Association of State Highway Officials originally formulated plans for a series of accelerated traffic loading tests on highways early in 1950. The tests were to be conducted as a basis for support of proper legal load limits. The Maryland Road Test #1 already planned by the Inter-Regional Council on Transportation was to have been followed by additional tests on other concrete pavements and also on flexible surfaces. The recently completed and reported on WASHO project advanced greatly highway research progress on flexible pavements of various design characteristics under a number of different highway loadings.

Continuous work on the part of the AASHO Highway Transport Committee and various sub-committees has brought planning for the larger scale AASHO project to the point where construction of test pavements is about to begin. The Highway Research Board has been asked by the Association to direct the project. The financing plan is a contractural agreement between each state highway department and the Bureau of Public Roads under which the Bureau will pay each state's share of the estimated cost of the project direct to the Highway Research Board, the monies to come from the 1 1/2 percent highway planning survey funds allocated to the respective states. Several non-public associations of allied industries will assist with the financial support. Special arrangements will be made to compensate the Illinois Division of Highways for removing unnecessary parts of the test setup after the completion of the tests.

Each of the state highway departments has named qualified representatives to serve on Regional Advisory Committees. A National Advisory Committee for the project is made up of three representatives from each of the four AASHO districts, these representatives selected from among the regional representatives. In addition, the National Committee includes competent representatives from the supporting interested groups. The composition of this National Advisory Committee is as follows:

Mr. A. A. Anderson
Chief Highway Consultant
Portland Cement Association

Mr. Ralph R. Bartelsmeyer
Chairman, AASHO Highway Transport Committee, and
Chief Highway Engineer
Illinois Division of Highways

Mr. D. Kenneth Chacey
Special Assistant for Transportation Engineering
Office of the Chief of Transportation
Department of the Army

Mr. W. E. Chastain, Sr.
Engineer of Physical Research
Illinois Division of Highways

Mr. Harold F. Clemmer*
Engineer of Materials and Standards
District of Columbia Department of Highways

Mr. H. A. Mike Flanakin
Highway Engineer
American Trucking Associations, Inc.

Mr. Carl E. Fritts*
Vice President for Engineering
Automotive Safety Foundation

*ASCE Members.

Mr. E. L. Hollifield
Ford Motor Company

Mr. E. H. Holmes
Deputy Commissioner
Bureau of Public Roads

Mr. Walter C. Hopkins
Deputy Chief Engineer
Maryland State Road Commission

Mr. John B. Hulse
Managing Director
Truck Trailer Manufacturers' Ass'n.

Mr. W. A. Dennison
Economist
American Petroleum Industry Committee
(Rep. Petroleum Industry)

Professor Ralph E. Fadum*
Head, Civil Engineering Department
North Carolina State College

Mr. E. A. Finney*
Ass't. Testing and Research Engineer
Michigan State Highway Department

Dr. Miles S. Kersten
University of Minnesota

Mr. J. L. Land*
Chief Engineer
Bureau of Materials and Tests
Alabama State Highway Department

Mr. R. E. Livingston
Planning and Research Engineer
Colorado Department of Highways

Mr. L. C. Lundstrom
Assistant Director
General Motors Proving Ground
(Rep. Automobile Manufacturers' Ass'n.

Mr. Burton W. Marsh*
Director, Traffic Engineering and Safety Department
American Automobile Association

Professor R. A. Moyer*
Institute of Transportation and Traffic Engineering
University of California

Mr. Lawrence K. Murphy*
Construction Engineer
Maine State Highway Commission

Mr. Francis N. Hveem*
Materials and Research Engineer
California Division of Highways

Mr. A. E. Johnson*
Executive Secretary
American Association of State Highway Officials

Mr. Roy E. Jorgensen*
Engineering Counsel
National Highway Users Conference

Mr. R. L. Peyton*
Engineer of Research
State Highway Commission of Kansas

Mr. T. E. Shelburne*
Director, Highway Investigation and Research
Virginia Department of Highways

Mr. George M. Sprowls
Manager, Highway Transportation Dept.
Goodyear Tire and Rubber Company
(Rep. Tire Industry)

Mr. H. O. Thompson
Testing Engineer
Mississippi State Highway Department

*ASCE Members.

Mr. Arvin S. Wellborn*
Chief Engineer
The Asphalt Institute

Mr. W. C. Williams*
Deputy State Highway Engineer
Oregon State Highway Department

Mr. Rex M. Whitton*
President, American Association of State Highway Officials, and
Chief Engineer
Missouri State Highway Department

Mr. J. C. Young*
Chairman, AASHO Committee on Design and
Engineer of Design
California Division of Highways

The Illinois Division of Highways has accepted the assignments of preparing the construction plans and specifications for the project, negotiating for right-of-way and conducting location and soil surveys. Much of this work already has been completed. Barring unexpected delays, it will be possible to let a grading contract in June of this year.

There follows a general description of the test project, taken directly from Mr. Burggraf's report:

"As tentatively outlined by the Working Committee of AASHO the test will be made on a four-lane divided highway, to be constructed as part of an eight-mile relocation of U.S. 6. Four test loops each approximately 7,600 feet in length, will be provided by connecting the divided roadway with turn-arounds. Each loop will have two test lanes with concrete pavement on one side of the dividing strip and bituminous pavement on the other side. Each loop will be divided into sections with pavement varying in thickness to represent existing roads and possible future design requirements. There will be similar variations in the paired test lanes of each loop. Eight bridges of varied design and construction are included in the tests.

Truck-tractor semi-trailers will be used as the test vehicles. Single-axle loads varying from 10,000 to 30,000 pounds and tandem axle loads from 20,000 to 50,000 pounds will be applied for a period of two years. More than a million axle loads will be applied on each test section. The trucks will be driven around the loops in the direction of normal traffic, applying the single axles on the inside lanes and the tandem axles on the outside lanes.

Two seasons will be required to construct the highway and install the various electronic and mechanical instruments to record the effects of repeated loadings. After two years of testing, another year will be required for post-testing and analysis of results and report writing.

This project is being financed cooperatively by all the State highway departments except one, the Bureau of Public Roads, Department of Defense, Automobile Manufacturers Association and other allied sectors of industry.

High-speed electronic computers will be used to keep the analysis of the test data up to date and to make possible interim findings of significant value to highway construction programs.

*ASCE Members.

The test will cost approximately 12 million dollars and will last approximately five years. During that time it will uncover a great deal of information that will be essential to future highway engineering and also to highway financing."

COMMITTEE ON GEOMETRICS OF HIGHWAY DESIGN

Wilson T. Ballard, Chairman of this committee, reports that he has, "undertaken to seek out and assemble all available information as to the activities and accomplishments of the various agencies active and interested in [highway geometrics], especially the activities of the AASHO, the Highway Research Board and the Institute of Traffic Engineering."

When this information has been collected, Mr. Ballard intends to outline a program of work for the committee and to seek direction from the proper authorities as to means of implementing the work.

It is expected that this committee will meet at the time of the June Meeting of the Society in Knoxville.

Members of this committee are: Wilson T. Ballard, Chairman, Jacob C. Young, Ralph L. Fisher, Conrad H. Lang, and Donald W. Loutzenheiser.

COMMITTEE ON HIGHWAY PLANNING AND FINANCE

This active committee has met several times for discussions directed along two general lines: (1) to decide on a study program in which various members of the committee or the entire committee might engage, and (2) to decide on papers or topics which might result in papers for presentation at an ASCE meeting.

Chairman Ralph A. Moyer of this committee reports further as follows:

"There are two major subjects or topics which were discussed at length by the Committee at our January meeting and again at the meeting in March. One subject which has been of special interest to the Committee deals with a critical review and appraisal of the state-wide highway planning surveys and the results obtained to date combined with a discussion of future objectives and applications of planning survey data. The other subject relates to a study of the Federal interest in various highway systems and the allocation of Federal funds (Federal-aid) for the construction of streets and highways in the various highway systems.

In regard to the planning surveys the Committee has recognized that the planning surveys have now been conducted in all of the 48 states over a period of 20 years. The objectives and uses made of planning survey data have varied considerably both over the 20-year period and in the applications of the planning survey data by the various individual states. It is obvious that some states are making better use of the planning survey data than others. A few states have carried out only certain phases of the planning surveys and are not making effective use of the planning survey data for advance planning, as for example, over a 5-year period.

In a study of the scope and objectives of future planning surveys and their applications, the Committee realizes that present legislation being considered by the Congress, if it is enacted into law, will have an important bearing on what the future trends will be in regard to these items. Thus, if the 1-1/2 percent provision for financing the planning surveys remains in effect with a $2-1/2 billion per year Federal Highway appropriation, many phases of the planning survey program would then, no doubt, be expanded and revised. In 1955-56 the expenditures for highway planning and finance studies will total approximately $21,000,000 under an $875,000,000 Federal-aid program. Under a greatly expanded Federal-aid program, the expenditures for the highway planning surveys, highway needs and finance studies can and should be increased in about the same proportion as the increase in Federal-aid. A review of planning survey procedures, objectives, results and their application, therefore, should be both a timely and worthy subject for study by the Committee.

The other subject which has been discussed by the Committee for adoption in a study program referred to above relates to a study of the Federal interest in various highway systems and a critical review and analysis of the various formulas for the allocation of Federal funds for the construction of streets and highways in the various highway systems. The legislation now under consideration by the Congress provides for the early completion of the Interstate System as a major responsibility of the Federal government with 90 percent of the cost of construction of the Interstate System to be financed with Federal funds. It has been proposed that the Federal funds should be allocated to each state on the basis of the estimates of highway needs on the Interstate System in each state.

There is need for a study to rationalize Federal-aid policies in the allocation of Federal-aid. Thus, Federal-aid has been justified on constitutional grounds of providing for national defense, establishment of post roads, furtherance of interstate commerce and to promote the general welfare. Federal-aid has made many important contributions to our highway plant, such as stimulation of more efficient highway administration, raising standards of construction and maintenance, and for promoting coordinated planning of highway systems. Federal-aid has promoted a high degree of uniformity in highway development in all parts of the nation. It has recognized varying highway needs and inequalities in the fiscal resources of the States and has helped to equalize tax efforts and highway development in all states. Federal-aid has been provided in recognition of the Federal interest or responsibility for highways in the western States with large Public Land holdings. These are all important factors which warrant further study and analysis. One of the basic factors indicating the National or Federal interest in a particular highway is the volume in percent of the total of interstate traffic (vehicles) and interstate commerce (value of good and services) which use or are transported over the particular highway. As far as I know, no published data are available to indicate the percentages of interstate traffic and commerce on the various highways in the Federal-aid systems. In any attempt to rationalize Federal-aid financing policies, information along these lines would serve a useful purpose.

If the proposals now being considered by the Congress for financing the $27 billion Interstate System are enacted into law, it is reasonable to expect that the Bureau of Public Roads will be called upon to administer the Act for the financing and construction of the Interstate System. A new policy for the determination of highway needs on the Interstate System in each state will then very likely be adopted by the Bureau of Public Roads. Such a policy will, no doubt, include revisions in the planning surveys and in the application of the results of the planning surveys in each state for the determination of highway needs on the Interstate System and also on the other Federal-aid systems in each state. A study of the Federal interest in the various highway systems and of a new policy for the determination of highway needs in each state, and for the allocation of Federal-aid to the various states is in our opinion a timely and challenging subject for study which should yield some excellent ASCE papers if the proposed legislation is enacted by the Congress and if the many other factors influencing such a study can be resolved by the Committee and others engaged in such a study.

The Committee has requested Mr. Lynch to discuss the above proposals with other members of the Bureau of Public Roads staff who occupy responsible positions covering various phases of the highway planning surveys, highway needs studies and Federal-aid financing. We will need a large amount of statistical and factual data to support these studies which the BPR is probably the only agency in a position to furnish to the Committee."

Members of this committee are: Ralph A. Moyer, Chairman, John Clarkeson, Thomas J. Fratar, Lowell E. Gregg, Roy E. Jorgensen and John T. Lynch.

COMMITTEE ON HIGHWAY TRAFFIC ENGINEERING

Wilbur Smith, Chairman of this group, reports difficulties in holding committee meetings because of wide geographical distribution of the membership. In spite of this handicap, Mr. Smith has, through correspondence and discussions with individual members, accomplished substantial progress.

Mr. Smith reports that the purpose of this committee,

". . .shall be to give attention to the broad aspects of traffic engineering, particularly as they relate to the planning and design of highway transportation systems and facilities. The committee will study and foster the development of knowledge that will aid in bridging the gap between the traffic operational requirements and the other highway engineering requirements of roads, streets and highways and terminal facilities. The committee should encourage appropriate papers and reports for presentation before sessions of the Highway Division of the Society, and may seek the cooperation of the Institute of Traffic Engineers, whenever appropriate."

Within his committee, Mr. Smith finds agreement that,

"1) For regional and annual meetings, it would be good if the Highway Division could sponsor at least one or two presentations by traffic engineers. An idea of potential papers can be had by reviewing the work published by these traffic engineers in other media.

2) Members of the committee should develop or arrange for preparation of articles suitable for publication in 'Civil Engineering.'

3) A main function of the committee will be to reach engineers who do not ordinarily have contact with traffic engineering journals and conferences.

4) The committee will not undertake directly any research or special studies.

5) From time to time, the committee will present questions and topics to officers of ASCE for review and possible reference to other committees for better integration of traffic engineering principles and objectives with broader highway and civil engineering activities."

Although small in numbers, this committee represents a well diversified cross section of civil engineering.

Members of this committee are: Wilbur S. Smith, Chairman, Donald M. McNeil, Burton W. Marsh, Mike H. A. Flanakin and George M. Webb.

Newsletter Editor:
George H. Leland
Edwards, Kelcey and Beck
3 William Street
Newark 2, New Jersey

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper numbers are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 861 is identified as 861 (SM1) which indicates that the paper is contained in issue 1 of the Journal of the Soil Mechanics and Foundations Division.

VOLUME 81 (1955)

MAY: 679(ST), 680(ST), 681(ST), 682(ST)[c], 683(ST), 684(ST), 685(SA), 686(SA), 687(SA), 688(SA), 689(SA)[c], 690(EM), 691(EM), 692(EM), 693(EM), 694(EM), 695(EM), 696(PO), 697(PO), 698(SA), 699(PO)[c], 700(PO), 701(ST)[c].

JUNE: 702(HW), 703(HW), 704(HW)[c], 705(IR), 706(IR), 707(IR), 708(IR), 709(HY)[c], 710(CP), 711(CP), 712(CP), 713(CP)[c], 714(HY), 715(HY), 716(HY), 717(HY), 718(SM)[c], 719(HY)[c], 720(AT), 721(AT), 722(SU), 723(WW), 724(WW), 725(WW), 726(WW)[c], 727(WW), 728(IR), 729(IR), 730(SU)[c], 731(SU).

JULY: 732(ST), 733(ST), 734(ST), 735(ST), 736(ST), 737(PO), 738(PO), 739(PO), 740(PO), 741(PO), 742(PO), 743(HY), 744(HY), 745(HY), 746(HY), 747(HY), 748(HY)[c], 749(SA), 750(SA), 751(SA), 752(SA)[c], 753(SM), 754(SM), 755(SM), 756(SM), 757(SM), 758(CO)[c], 759(SM)[c], 760(WW)[c].

AUGUST: 761(BD), 762(ST), 763(ST), 764(ST), 765(ST)[c], 766(CP), 767(CP), 768(CP), 769(CP), 770(CP), 771(EM), 772(EM), 773(SA), 774(EM), 775(EM), 776(EM)[c], 777(AT), 778(AT), 779(SA), 780(SA), 781(SA), 782(SA)[c], 783(HW), 784(HW), 785(CP), 786(ST).

SEPTEMBER: 787(PO), 788(IR), 789(HY), 790(HY), 791(HY), 792(HY), 793(HY), 794(HY)[c], 795(EM), 796(EM), 797(EM), 798(EM), 799(EM)[c], 800(WW), 801(WW), 802(WW), 803(WW), 804(WW), 805(WW), 806(HY), 807(PO)[c], 808(IR)[c].

OCTOBER: 809 (ST), 810 (HW)[c], 811 (ST), 812 (ST)[c], 813 (ST)[c], 814(EM), 815(EM), 816(EM), 817(EM), 818(EM), 819(EM)[c], 820(SA), 821(SA), 822(SA)[c], 823(HW), 824(HW).

NOVEMBER: 825(ST), 826(HY), 827(ST), 828(ST), 829(ST), 830(ST), 831(ST)[c], 832(CP), 833(CP), 834(CP), 835(CP)[c], 836(HY), 837(HY), 838(HY), 839(HY), 840(HY), 841(HY)[c].

DECEMBER: 842(SM), 843(SM)[c], 844(SU), 845(SU)[c], 846(SA), 847(SA), 848(SA)[c], 849(ST)[c], 850(ST), 851(ST), 852(ST), 853(ST), 854(CO), 855(CO), 856(CO)[c], 857(SU), 858(BD), 859(BD), 860(BD).

VOLUME 82 (1956)

JANUARY: 861(SM1), 862(SM1), 863(EM1), 864(SM1), 865(SM1), 866(SM1), 867(SM1), 868(HW1) 869(ST1), 870(EM1), 871(HW1), 872(HW1), 873(HW1), 874(HW1), 875(HW1), 876(EM1)[c], 877 (HW1)[c], 878(ST1)[c].

FEBRUARY: 879(CP1), 880(HY1), 881(HY1)[c], 882(HY1), 883(HY1), 884(IR1), 885(SA1), 886(CP1), 887(SA1), 888(SA1), 889(SA1). 890(SA1), 891(SA1), 892(SA1), 893(CP1), 894(CP1), 895(PO1) 896(PO1), 897(PO1), 898(PO1), 899(PO1), 900(PO1), 901(PO1), 902(AT1)[c], 903(IR1)[c], 904 (PO1)[c], 905(SA1)[c].

MARCH: 906(WW1), 907(WW1), 908(WW1), 909(WW1), 910(WW1), 911(WW1), 912(WW1), 913 (WW1)[c], 914(ST2), 915(ST2), 916(ST2), 917(ST2), 918(ST2), 919(ST2), 920(ST2), 921(SU1), 922(SU1), 923(SU1), 924(ST2)[c].

APRIL: 925(WW2), 926(WW2), 927(WW2), 928(SA2), 929(SA2), 930(SA2), 931(SA2), 932(SA2)[c], 933(SM2), 934(SM2), 935(WW2), 936(WW2), 937(WW2), 938(WW2), 939(WW2), 940(SM2), 941 (SM2), 942(SM2)[c], 943(EM2), 944(EM2), 945(EM2), 946(EM2)[c], 947(PO2), 948(PO2), 949(PO2), 950(PO2), 951(PO2), 952(PO2)[c], 953(HY2), 954(HY2), 955(HY2)[c], 956(HY2), 957(HY2), 958 (SA2), 959(PO2), 960(PO2).

MAY: 961(IR2), 962(IR2), 963(CP2), 964(CP2), 965(WW3), 966(WW3), 967(WW3), 968(WW3), 969 (WW3), 970(ST3), 971(ST3), 972(ST3)[c], 973(ST3), 974(ST3), 975(WW3), 976(WW3), 977(IR2), 978(AT2), 979(AT2), 980(AT2), 981(IR2), 982(IR2)[c], 983(HW2), 984(HW2), 985(HW2)[c], 986(ST3), 987(AT2), 988(CP2), 989(AT2).

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c. Discussion of several papers, grouped by Divisions.

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